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Aeronautical Engineering REVIEW

July, 1955

Douglas YC-124B powered by four 5550 h.p. Pratt & Whitney T-34 turboprop engines.

How the Holley "hidden co-pilot" does two jobs with one handle control

Throughout the entire operational range of the new Douglas YC-124B, engine power and propeller governor setting must be precisely coordinated. This has always been a "two-handle" job but in this new airplane the job is done with a single control lever and the help of a Holley Power Control which functions like a "hidden co-pilot".

One of these controls installed on each 5550 horsepower Pratt & Whitney Aircraft T-34 engines automatically senses altitude, air temperature and speed and feeds the information to its nerve center—a series of precision manufactured 3-dimensional cams. These cams continuously interpret this information in terms of engine power which is automatically adjusted through precise metering of fuel by the control.

The Holley Power Control not only coordinates the engine and propeller for all forward thrust conditions but also controls the vital reversing of thrust necessary to reduce the aircraft's landing roll.

Designed, developed and manufactured by Holley, the "hidden co-pilot" is dependable, easy to service, compact and lightweight—four qualities that always distinguish Holley aviation equipment.

HOLLEY Carburetor Co.

11955 E. NINE MILE ROAD
VAN DYKE, MICHIGAN

LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES

Aeronautical Engineering Review

Vol. 14—No. 7 July, 1955

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Cover—Cessna Aircraft Company's CH-1 helicopter, with an all-metal body resembling that of a private plane, is reported to be capable of cruising at 100 to 120 m.p.h., climbing at 1,150 ft. per min., and hovering above 11,000 ft. with two persons aboard. It has a 260-hp. Continental engine. Maximum gross weight is 3,000 lbs.; useful load, 1,025 lbs., and endurance, 3.8 hours. The two-bladed rotor is 35 ft. in diameter.

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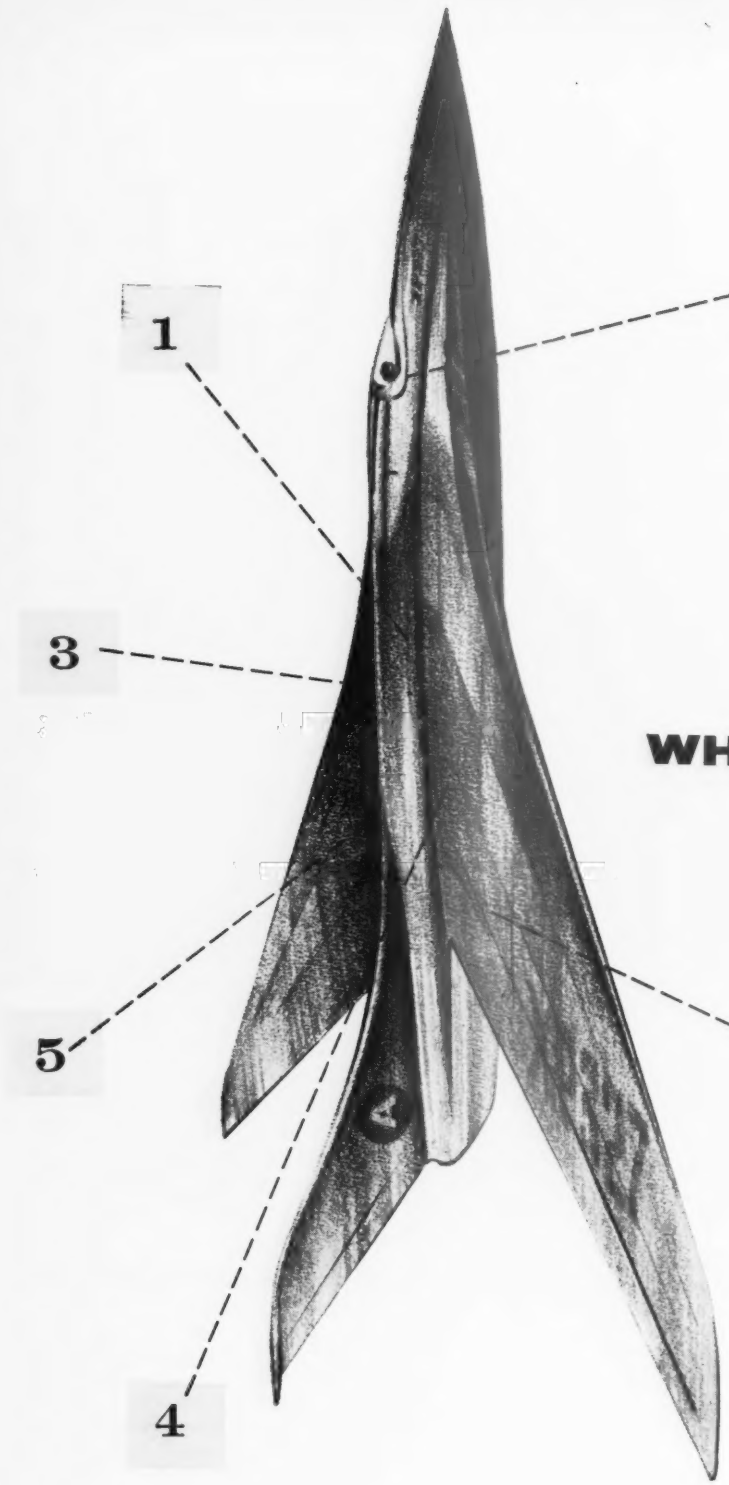


WHAT JANITROL'S

IAS News

A Record of People and Events of Interest to Institute Members

Seattle Conference August 8–10

Papers and Program Announced for Second National Turbine-Powered Air Transportation Meeting

THE INSTITUTE OF THE AERONAUTICAL SCIENCES' second national meeting on Turbine-Powered Air Transportation will be held in Seattle, Washington, August 8–10. The Olympic Hotel will be headquarters for the 3-day annual event, which last year attracted almost 600 delegates.

There will be five technical sessions, two luncheons, a dinner, and a field trip to Boeing Airplane Company's new flight-test center. Full details of the program are being mailed to all IAS members. Requests for hotel reservations should be addressed to: IAS Turbine-Powered Air Transportation Meeting, Olympic Hotel, Seattle, Wash.

The meeting will open at 9:00 a.m., Monday, August 8, with registration at 8:30 a.m. All sessions will be held in the Spanish Ballroom of the hotel. They will run from 9:00 a.m. to 12:00 noon and from 2:00 to 5:00 p.m.

Thirteen papers will be presented in morning and afternoon sessions on the first 2 days and in a morning session the last day. Six of the papers will be by foreign authors. Emphasis will be placed on design and operating problems of large jet transports, including turboprops and seaplanes, and on problems of gas-turbine engines.

Although the list of papers to be presented was not complete at press time, the following have been scheduled tentatively:

"Convair's Turboprop Airplanes," by John Thomas Ready, Jr., Assistant Project Engineer, Convair, A Division of General Dynamics Corporation.

"United States Airworthiness Performance and Operating Rules as Applied to the Viscount," by Derek J. Lambert, Chief Development Engineer (Civil), Vickers-Armstrongs Limited (Aircraft Division) of England.

"Large Turbojet Water-Based Aircraft in the Transport Role," by Chauncey F. Bell, Project Engineer, Advanced Design Department, The Glenn L. Martin Company.

"Considerations on Design and Development of the SE 210 'Caravelle,'" by Jacques A. M. LeCarme, Technical Adviser and Test Pilot, and Jean P. Gelos, Air Lines Technical Relations Engineer, Société Nationale de Constructions Aeronautiques du Sud-Est of France.

"Characteristic Qualities and Design Problems of the Fokker F-27 Twin-Propeller Turbine Transport," by H. C. van Meerten, Chief Engineer, N. V. Koninklijke Nederlandse Vliegtuigenfabriek Fokker, Holland.

"Viscount Operations," by Jack T. Dyment, Director of Engineering, Trans-Canada Air Lines.

"Ground Handling of Jet Transports," by R. D. Kelly, Superintendent of Technical Development, United Air Lines, Inc.

"The Role of the Turbine-Powered Seaplane in the Air Logistic Arm of the Navy," by Rear Adm. James S. Russell, Chief of the Bureau of Aeronautics, Navy Department.

"Effect of Civil Turbine-Powered Transport Aircraft on the Air Traffic Control System," by Charles W. Carmody, Chief, Operational Procedures Branch, Airways Operations Division, Civil Aeronautics Administration.

"Technical Development and the Commercial Requirement," by Clifford H. Jackson, Manager, Operations Development Unit, British Overseas Airways Corporation.

"Boeing 707 Program—Progress Report," by George C. Martin, Chief Engineer, Boeing Airplane Company. A panel including four other Boeing engineers will assist in the presentation of this paper.

Another paper will be presented by an engineer representing the General Electric Company.

Chairman G. W. (Bill) Taylor

The annual dinner will be held in the Spanish Ballroom Tuesday evening at 7:00 o'clock. The luncheons—minus speeches—are scheduled for Monday and Tuesday at 12:30 in the Olympic Bowl, a private dining room in the hotel.

The Boeing tour will take place Wednesday afternoon, August 10, from 12:30 to 4:00 p.m. Busses will leave the hotel shortly after the morning session is concluded, and those who attend will be guests of the Boeing Airplane Company for luncheon. The program will include an inspection of turbine-powered aircraft at the Boeing Flight Test Center and, for those who desire it, a short tour of the plant. Toward the end of the tour, one of the busses will go directly to the Seattle-Tacoma Airport to accommodate those departing on early flights.

Special arrangements will be required for any person who is not a United States citizen and who wishes to participate in the Boeing field trip.

The Program Committee of the Seattle Section, headed by G. W. (Bill) Taylor, is in charge of arrangements for the National Turbine-Powered Air Transportation Meeting. The other committee members are L. B. Gratzer, Bob Boring, Dick Haase, Vaughan L. Blumenthal, Mark E. Kirchner, F. A. Maxam, Donald W. Finlay, and M. L. Olason.

Southeastern Student Conference Held at Virginia Polytechnic Institute

The Sixth Annual Southeastern Regional Conference for Student Branches of the IAS was held April 7–9 at Virginia Polytechnic Institute, Blacksburg, Va. Purpose of the conference was to give students an opportunity to present technical papers before a qualified audience and to provide an incentive that would encourage them to write papers for oral presentation. At the same time matters of mutual interest to the Student Branches were discussed.

The 3-day conference consisted of five technical sessions, an inspection tour of the V.P.I. aeronautical laboratory, a banquet, and several informal gatherings.

Opening with registration on Thursday morning, April 7, the conference got under way officially at 1:30 p.m. when Walter S. Newman, President of V.P.I., gave the welcoming address. He was followed by John W. Whittemore, Dean of Engineering and Architecture.

Leon Z. Seltzer, Head of the Aeronautical Engineering Department at West Virginia University, started the fourth session with a talk on "The Education That Fits Your Future."

At the banquet Friday night, the speaker was Victor G. Szebehely, of the staff of the David Taylor Model Basin. He gave a humorous and informative lecture on the "Development of the Present State of Knowledge in Hydro- and Aero-Mechanics."

The final session on Saturday morning was followed by the presentation of awards and a business meeting. It was decided to hold next year's convention at the University of Alabama.

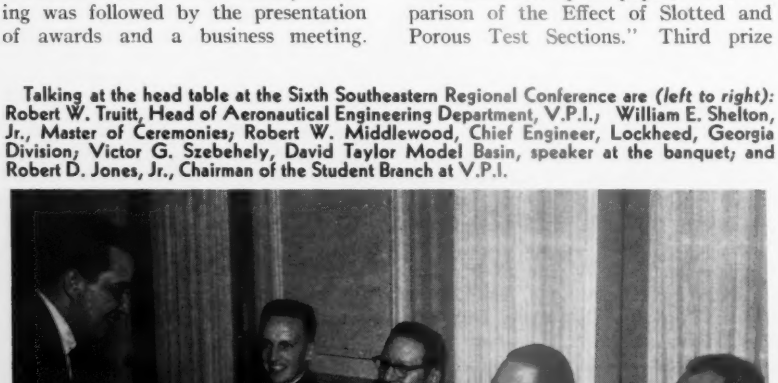
Robert W. Middlewood, Chief Engineer of Lockheed's Georgia Division, congratulates the undergraduate award winners at the Southeastern Regional Conference. *Left to right:* Frank J. Boyce and Arthur C. Bruce, V.P.I., who won second prize jointly; H. L. Mooney, U.S. Naval Academy, the top winner; Mr. Middlewood; and Earl Bailey, Mississippi State College, who placed third.

Twenty-five papers were presented during the conference. The prize for the best undergraduate paper was won by H. L. Mooney, of the United States Naval Academy, for his paper, "Ionoprint, Air-borne High-Speed Electronic Printer." The second prize was won by Frank J. Boyce and Arthur C. Bruce, of V.P.I., for their joint paper, "A Comparison of the Effect of Slotted and Porous Test Sections." Third prize went to Earl Bailey, of Mississippi State College, for "Some Experiments Concerning Dynamic Strains in Vibrating Beams." The graduate award went to James S. Hayden, Mississippi State College, for his discussion of "High Lift Aspects of the Slip Stream Effect." The following students were cited for honorable mention: Raymond M. Hollub, of the University of Alabama and Georgia Division of Lockheed Aircraft, and Robert D. Jones, Jr., of V.P.I.

The schools represented at the conference were Alabama Polytechnic Institute, Georgia Institute of Technology, Mississippi State College, North Carolina State College, University of Alabama, University of Florida, University of Maryland, University of Virginia, U.S. Naval Academy, West Virginia University, and Virginia Polytechnic Institute. The total number attending the conference exceeded 100.

Midshipman Mooney's prize paper will be included in the 1955 edition of *First Award Papers* which will be published in September under the auspices of the Minta Martin Aeronautical Student Fund. Similarly, along with the First Prize winners from five other IAS Regional Student Conferences, Midshipman Mooney is eligible for selection as one of two national winners (graduate and undergraduate) who will each receive an honorarium derived from the Minta Martin Fund. The sponsorship of these activities by the Minta Martin Fund has proved to be a major source of encouragement and incentive to engineering students.

Talking at the head table at the Sixth Southeastern Regional Conference are *(left to right)*: Robert W. Truitt, Head of Aeronautical Engineering Department, V.P.I.; William E. Shelton, Jr., Master of Ceremonies; Robert W. Middlewood, Chief Engineer, Lockheed, Georgia Division; Victor G. Szebehely, David Taylor Model Basin, speaker at the banquet; and Robert D. Jones, Jr., Chairman of the Student Branch at V.P.I.



Eleven Colleges Represented at Texas Section's Third Southwestern Student Competition

Admiral Luis de Florez, pioneer naval aviator and IAS Fellow, speaking at the Awards Night Dinner of the Texas Section's Third Annual Southwestern Student Competition. Others in the photo are, *left to right:* John H. Boucher, Vice-Chairman, Texas Section; Howard F. Marx, Chairman, Texas Section; and Ernest W. Robischon, Western Region Manager, IAS.

The Third Annual Southwestern Student Competition, conducted by the Texas Section of the IAS, was held in Fort Worth, Tex., on April 21–23, at the Hilton Hotel. Twenty undergraduate and graduate students representing eleven colleges throughout the South and Middle West delivered papers on aeronautical subjects.

Four local aircraft companies underwrote the cost of the competition. The companies were Bell Aircraft Corporation; Chance Vought Aircraft, Incorporated; Convair, A Division of General Dynamics Corporation (Fort Worth); and Temco Aircraft Corporation.

After registration on Wednesday afternoon, April 20, the competition was opened on Thursday morning by Howard F. Marx, Chairman of the Texas Section. He welcomed the competing students, their faculty sponsors, and many guests and then relinquished the chair to G. H. Teeter, Student Competition Chairman, who outlined the conference events and rules and introduced the Chairmen of the various sessions.

There were four undergraduate sessions and one graduate session. One undergraduate session was held each morning of Thursday and Friday, April 21 and 22, and one each afternoon. The graduate session was held on Friday afternoon. The papers dealt with such diverse subjects as aerodynamics, structures, rockets, instrumentation, and helicopters. The sessions were attended by more than 60 registered guests from various colleges and nearby aircraft companies and by many more who were interested in some particular session.

Luncheons were held on Thursday and Friday. Top engineers from the sponsoring companies spoke at these gatherings. The general theme was "The Relationship Between the Engineer and Industry."

The speakers on Thursday were H. B. Gibbons, Chief of Development, Chance Vought Aircraft, Incorporated, and I. N. Palley, Vice-President for Engineering, Temco Aircraft Corporation. Mr. Gibbons discussed the managerial problems confronting the engineer as he moves up in his organization, and what he can expect of industry. He emphasized the significance of being able to work with and through other people. Mr. Palley carried on the theme by pointing out the necessity for the engineer to view modern technical problems in their broad, overall aspect before undertaking detailed investigations. He urged the understanding and use of the "systems concept" as a valuable tool in coping with the vast complexity of current and future technological endeavors.

On Friday, the luncheon speakers were R. L. Lichten, Chief Experimental Project Engineer, Texas Division, Bell Aircraft Corporation, and W. A. Clegern, Manager, San Antonio office, Convair Division of General Dynamics Corporation. Mr. Lichten spoke on what the industry expects of the young engineer. He outlined the requirements for the first few steps in advancement which the engineer normally takes. In particular, he indicated the need for an engineer to increase continually the scope of his thought and understanding if he desires to advance into the managerial ranks. Mr. Clegern discussed

(*Continued on page 88*)

Luncheon speakers confer with officers at the Third Annual Southwestern Student Competition in Fort Worth. From *left to right* are: I. Nevin Palley, Vice-President—Engineering, Temco Aircraft Corporation; Howard F. Marx, Chairman, Texas Section; John H. Boucher, Vice-Chairman; and Henry B. Gibbons, Chief—Development, Chance Vought Aircraft, Inc.

Winners Announced in St. Louis Section's Student Paper Competition

Winners in the St. Louis Section's Student Paper Competition are congratulated by Mayor Raymond R. Tucker. *Left to right:* Gene E. Maddux, Ohio State, first prize; Bernard E. Heyl, Indiana Tech, honorable mention; James L. Haugen, North Dakota, best oral presentation; Mayor Tucker; James R. Sorem, University of Kansas, second prize; William Mains, Jr., Kansas, honorable mention; and Donald M. Gates, Kansas, third prize.

The St. Louis Section held its Second Annual Student Paper Competition during the spring of 1955. The competition was directed by the Educational Committee under the chairmanship of Charles J. Kippenhan, Professor, Washington University, and was sponsored by the Minta Martin Aeronautical Student Fund. Members of the Educational Committee are Harold Hertenstein, of Parks College of Aeronautical Technology; Darrell Massey, Westinghouse Electric Corporation; and Leo I. Mirowitz, T. P. Brooks, and Howard Young, of McDonnell Aircraft Corporation.

Undergraduate engineering students attending 84 schools in 15 Midwestern states were invited to submit papers on subjects pertaining to the aeronautical field. Cash prizes were awarded for the best papers, and an additional cash prize was given for the best oral presentation of one of the six winning papers. First prize for the written papers was $100; second prize, $75; and third prize, $50. Three other papers received honorable mention. The prize for the best oral presentation was $75. The winners also received travel allowances for their trips to St. Louis.

Two committees were appointed to judge the papers. The Written Paper Committee consisted of J. T. Mayes, Chairman, McDonnell Aircraft Corporation; Lewis Raiche, American Car and Foundry Company; and John Noyes, Sverdrup and Parcel. On the Oral Presentation Committee were H. D. Barkey, Chairman, and L. A. Goran, N. B. Moore, and M. D. Etherton, all of McDonnell Aircraft.

The competition culminated on Thursday, May 5, with the presentation of the papers at a special afternoon meeting and the awarding of prizes at the Section's Annual Dinner Meeting that evening.

Following are the winners and the titles of their papers: *First Prize*, Gene E. Maddux, Ohio State University, "The Use of Nuclear Reactors for the Propulsion of Aircraft"; *Second Prize*, James R. Sorem, University of Kansas, "Lift Loads on the Horizontal Tail of an L-13 Airplane"; and *Third Prize*, Donald M. Gates, University of Kansas, "Comparison of the Theoretical and Experimental Deflection of a Model Tension Field Beam from the Measured Properties of the Materials."

Mayor Raymond R. Tucker, of St. Louis, guest speaker at the dinner of the St. Louis Section, is shown seated while Toastmaster A. F. Matthews has a turn at the microphone.

Those who received honorable mention were Bernard E. Heyl, Indiana Technical College, "Pressure Variations Imposed by Fluids in Subsonic Flow"; William Mains, Jr., University of Kansas, "A Comparison of the Ultimate Loads Carried by Small Wagner Beams to the Theoretical Ultimate Loads"; and Jimmy Leroy Haugen, University of North Dakota, "Human Engineering of Airplane Cockpits." Mr. Haugen also won the award for the best oral presentation.

Invitations to attend the activities of May 5 were extended to the schools participating in the competition. In addition to the winners, about 80 students and faculty members from the University of Kansas, Washington University, and Parks College assembled in the McDonnell Aircraft Corporation plant for an extensive tour of its facilities, with Section Chairman Edward M. Flesh making the welcoming address. The tour and luncheon lasted until 2:30 p.m., when the oral presentation of the papers took place. The group also saw motion pictures of the McDonnell F2H-2 Banshee operating in Korean waters and of the first flights of the McDonnell F-101 Voodoo. McDonnell Aircraft was host at the luncheon.

The day's activities ended on a high note with the Section's Annual Dinner Meeting, this year held in conjunction with the St. Louis Section of the Society of Automotive Engineers. The meeting was held in the Gatesworth Hotel in St. Louis and was attended by about 135 persons, including several students and faculty members from out of town. The Dinner Meeting was arranged by the Program Committee headed by F. C. Phillips.

Toastmaster A. F. Matthews, of McDonnell, opened the meeting by introducing several guests at the head table. After dinner, Kendall Perkins, Vice-President—Engineering, McDonnell Aircraft Corporation, introduced the principal speaker of the evening, the Hon. Raymond R. Tucker, Mayor of the City of St. Louis.

Mayor Tucker was well qualified to speak before a technical group. After obtaining his A.B. from St. Louis Uni-

(*Continued on page 90*)

Los Angeles Section Conducts West Coast Conference for Students, Faculty, and Industry

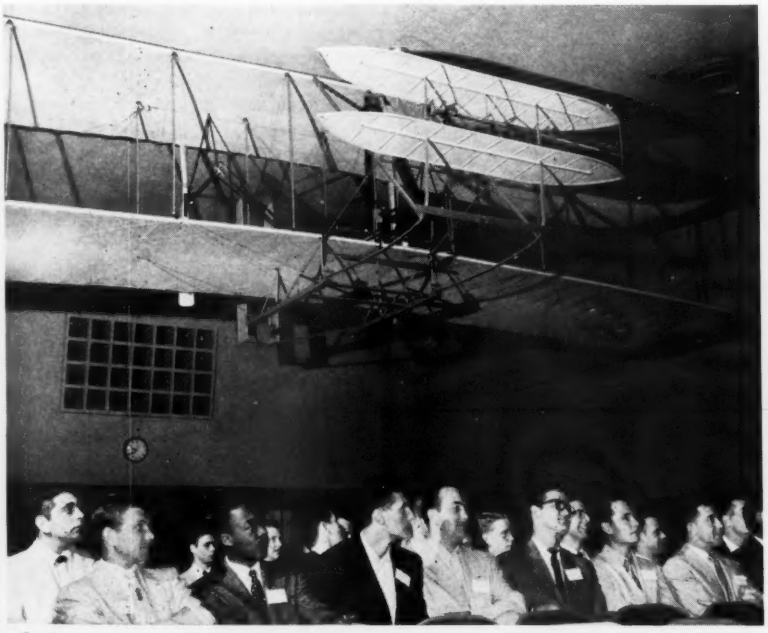
The Fifth Annual West Coast Conference of the IAS Student Branches and the Second Annual Industry-Faculty Conference were held May 11–13 at the IAS Building in Los Angeles. Approximately 150 students from eleven West Coast universities and colleges attended the meeting, which opened at 9:00 a.m., Wednesday, May 11, with an address of welcome by George R. Mellinger, Vice-Chairman of the Los Angeles Section.

Mr. Mellinger, who is Chief of Flight Test, North American Aviation, Inc., was Chairman of the morning session, at which four undergraduates presented their papers. The titles and authors were "Foamed Plastic as an Aluminum Column Stabilizing Agent," by George Schiner, University of California, Los Angeles; "Wedding of the Turbojet Transport to Present Aircraft Terminal Facilities," by Frank J. Helms, California State Polytechnic College; "Application of the Analog Computer to the Solution of Statically Indeterminate Beam Problems," by Victor Peterson, Oregon State College; and "An Experimental Investigation of the Effect of Gap and Stagger on Tandem Wing Aircraft," by Malcolm L. Matthews, University of Washington.

Following the morning session, Douglas Aircraft Company, Inc., was host at luncheon in the IAS Building.

Shown are the judges and two other leaders in the West Coast Conference of Student Branches. *Left to right:* Robert R. Templeton, North American Aviation, judge; Paul Strohm, TWA, Committee Chairman; George R. Mellinger, NAA, Vice-Chairman—Los Angeles Section; George N. Mangurian, Northrop Aircraft, judge; and Carl Babberger, Hughes Aircraft, judge.

Chairman of the afternoon session, at which four more undergraduate papers were read, was Richard G. Fuller, Aerodynamics Group Engineer, Lockheed Aircraft Corporation. Subjects covered were "Color Schlieren for Flow Visualization," by Richard M. Knox, Stanford University; "Design and Development of an Automatic Control System for a Vertical-Take-Off Model Airplane," by Leroy L. Presley, Oregon State College; "Construction and Operation of a Small Wind Tunnel," by Harold R. Wheelock, Northrop Aeronautical Institute; and "A Practical Aircraft for Pest Control Work," by Warren S. Wilson, California State Polytechnic College.



Students sit beneath the replica of the Wright Brothers' first plane as they listen to discussion at the Los Angeles Section's West Coast Conference of Student Branches. About 150 students attended.

Wednesday evening, at the Second Annual Industry-Faculty Conference, 75 people representing twelve schools and ten companies gathered for a buffet supper, at which Convair Division of General Dynamics Corporation was host. Paul Strohm, of Trans World Airlines, Inc., Chairman of the Student Activities Committee of the Los Angeles Section, introduced the topic of discussion—Engineering Scholarships. Clayton LaVene of Douglas, Tracy Brooks of Convair, and Joseph J. Schwarz of Lockheed gave a detailed outline of their scholarship programs. The group then discussed the benefits of these programs to industry and to universities. At the close of the discussion, a committee was appointed to make an exhaustive study of engineering scholarships.

Chairman of the Thursday morning student conference was Welko E. Gasich, Chief of Preliminary Design, Northrop Aircraft, Inc. Two papers were presented by graduate students: "The Effect of Pre-Stress upon the Fatigue of Notched Aluminum Specimens," by John Marion, University of California, Los Angeles, and "Simple Means for

(*Continued on page 90*)

More than 600 attended the Honors Night Dinner of the American Helicopter Society in the Mayflower Hotel, Washington. Speakers' table at left.

Bartram Kelley *(right)*, Chief Engineer of Bell's Helicopter Division, receives the Dr. Alexander Klemin Award from John Vest, President, AHS.

American Helicopter Society's Annual Forum Sets Record

Commercial operations, rather than the military applications that have held the spotlight in past meetings, were emphasized at the Eleventh Annual Forum of the American Helicopter Society, Inc., held in Washington April 28–30.

F. B. Lee, Administrator of Civil Aeronautics, U.S. Department of Commerce, delivered the keynote speech at the Society's Honors Night Dinner April 28 in the Grand Ballroom of the Mayflower Hotel. His subject was "The Helicopter—A New Dimension for Civil Aviation." Stanley Gewirtz, Executive Assistant to the President of the Air Transport Association, spoke at a luncheon the following day.

With more than 500 registered, this year's Forum was the largest ever held. Seventeen papers were presented in the 2 days of technical sessions. There also was a panel on helicopter operations. Members saw a demonstration and display of rotary-wing aircraft at the Anacostia Naval Air Station, as well as manufacturers' exhibits in the hotel. There were side events such as the Pioneers' Night Dinner and the Annual Meeting of the Twirly Birds.

Colonel William B. Bunker, Commandant of the Army's Transportation School at Fort Eustis, Va., was elected President of the American Helicopter Society. He is the first active military man to head the organization. Joseph Mashman, of Bell Aircraft Corporation, was chosen Secretary, and Hans Weichsel, Jr., also of Bell, became Treasurer.

Regional Vice-Presidents elected were Alb C. Ballauer, Major Gen. Frank A. Heileman, USA (Ret.), Frank MacMahon, Owen Q. Niehaus, Robert T. Wood, and Raymond A. Young.

At the Honors Night Dinner, Honorary Fellowships in the Society were bestowed upon Anton Flettner, President of Flettner Aircraft Corporation, and Comdr. William G. Knapp, of the Bureau of Aeronautics, Navy Department.

The Dr. Alexander Klemin Award "for notable achievement in the advancement of rotary-wing aeronautics" was presented to Bartram Kelley, MIAS, Chief Engineer of the Helicopter Division, Bell Aircraft Corporation. Carlyle C. Agar, Vice-President of Okanagan Helicopters Ltd., won the Capt. William J. Kossler Award "for greatest achievement in the practical

(Continued on page 92)

There were 43 industrial exhibits connected with the American Helicopter Society's Eleventh Annual Forum. Crowd kept exhibitors busy between sessions.

Helicopter show at Anacostia Naval Air Station offered demonstrations and exhibits on final day. The public attended this outdoor event.

Necrology

Ivan H. Driggs

Ivan H. Driggs, FIAS, Chief Scientist of the Naval Air Development Center, Johnsville, Pa., died of a heart attack on May 8. He was 61 years old.

Engaged in aircraft work as an engineer and designer since 1917, Mr. Driggs was a personal friend of the late Orville Wright and worked with him on several projects. He was associated with a number of companies before joining McDonnell Aircraft Corporation in 1939 as Vice-President and Chief Engineer. In 1941 he joined the Bureau of Aeronautics, Navy Department, becoming Director of the Research Division before he transferred to the NADC in January, 1954.

With two colleagues in BuAer, Mr. Driggs won the Navy League's Award of Merit last year for his part in developing vertical-take-off fighter planes. Years ago, he was credited with designing retractable landing gear. He was coauthor of the recent book, *Gas Turbines for Aircraft.*

Mr. Driggs received an honorary degree in Aeronautical Engineering from Stevens Institute of Technology in 1945. He had attended Michigan State College but did not graduate. He was a Fellow of the Royal Aeronautical Society. For the past 2 years he served on the Editorial Advisory Committee of the AERONAUTICAL ENGINEERING REVIEW, reviewing papers on aircraft design, structures, and materials for possible publication.

Surviving are his widow, the former Eva Wright, and a daughter. Burial was in Lansing, Mich.

J. D. M. Gray

James Douglas More Gray, MIAS, 112 Edith Drive, Toronto, Canada, died on March 24 after a short illness. He was 61.

A graduate of the Royal West of Scotland Technical College, Mr. Gray started his flying career at an early age in a Voisin biplane in 1911. He was a World War I aviator in the Royal Flying Corps.

Returning to Canada in 1931, Mr. Gray made a study of arctic flying and did extensive research toward opening up an arctic air route between Canada and Europe. This work lasted 2 years and took him on numerous flights to northern outposts and Iceland. During this period, he wrote for *Maclean's* magazine on the possibility of establishing a practical arctic air route.

Subsequently, Mr. Gray practiced as a consulting engineer. In 1939 he initiated a vast tooling program for production of the Handley-Page Hampden bomber by National Steel Car Company of Hamilton, Ont. At the outbreak of World War II, he organized a government project to give technical

Ivan H. Driggs

John H. Towers

training to young men about to enter the RCAF and the aircraft industry. After a while as principal of Galt Aircraft School, Mr. Gray joined the Royal Canadian Ordnance Corps, assisting in the design of armored vehicles.

While with Otaco, Ltd., of Orillia, Ont., Mr. Gray devised new methods of packing Mosquito aircraft parts and instruments for global shipment and wrote a booklet on export packing. Recently, he had been manager of the production division of C. A. Meadows & Associates, consulting engineers, of Toronto.

Mr. Gray was an Associate of the Royal Aeronautical Society. He leaves his widow, Philippa Rowe Gray, a son, and two daughters.

Arthur B. Schultz

Arthur B. Schultz, MIAS, of Western Springs, Ill., died on May 2 at the age of 51. He was a Senior Mechanical Engineer and Group Leader at the Atomic Energy Commission's Argonne National Laboratory, situated in Lemont, near Chicago.

Mr. Schultz entered the aircraft industry after graduating from University of Michigan in 1927 with a B.S. in Aeronautical Engineering. Later he spent several years with automotive and marine engine manufacturing plants in Detroit. From 1942 to 1947, as Chief Engineer of All American Aviation, Inc., he had a leading part in the development of air pickup devices and plane arresting devices. More than a dozen patents were issued in his name.

For a year before he joined the AEC in 1948, Mr. Schultz supervised chassis design of the proposed Tucker automobile and installation of its power plant, which was to be a six-cylinder, air-cooled aircraft engine.

Always interested in gliding, Mr. Schultz designed, built, and flew his own sailplane. For 5 years he was treasurer of the Soaring Society of America and was the author of several magazine articles on soaring.

Adm. John H. Towers

Admiral John Henry Towers, USN (Ret.), AFIAS, President of the Flight Safety Foundation, Inc., died of cancer on April 30 in St. Albans Naval Hospital, New York. He was 70 years old.

One of the first three naval aviators, he flew the Navy's first airplane in 1911 and set an endurance record for seaplanes of 6 hours and 10 min. in 1912. The same year, he was tossed out of an open-cockpit plane by a downdraft at 1,700 ft. over Chesapeake Bay. The pilot fell to his death, but Towers managed to grab a strut and fell with the plane. He was rescued, seriously injured. This accident led to the adoption of safety belts.

Admiral Towers was born in Rome, Ga., January 30, 1885. He was graduated from the U.S. Naval Academy in 1906 and rose to the rank of Com-

mander during the First World War. In 1919, he planned and commanded the first successful airplane flight across the Atlantic. Eight years later he took command of the Navy's first aircraft carrier, the U.S.S. "Langley."

The epic flight of the three Navy flying boats, which had started from Newfoundland, was hampered by fog near the Azores on May 16, 1919. The NC-3, commanded by Towers, and the NC-1 were forced down, but the NC-4 flew on to Horta, in the Azores, and eventually to Plymouth, England. Heavy seas prevented Commander Towers from getting his big, four-engined biplane into the air again, and he taxied 205 miles to a harbor. He received the Navy Cross for his leadership in the flight.

In 1928, Commander Towers was assigned to the Bureau of Aeronautics as Head of the Plans Division, and the following year he became Assistant Chief of the Bureau. In 1934, with the rank of Captain, he was named Commanding Officer of the Naval Air Station at San Diego.

After another tour of sea duty, Captain Towers returned to the Bureau of Aeronautics in 1938, and a year later was named its Chief with the rank of Rear Admiral. In this capacity he organized the Navy's mass production program for all types of planes. Total aircraft increased from 2,000 to more than 39,000. He greatly expanded the program for training pilots and ground officers.

In 1942, he became Commander, Air Force, Pacific Fleet, with the rank of Vice-Admiral. It was his job to supervise the development, organization, training, and supply of the growing carrier fleet, as well as of land-based Naval and Marine aviation. He was awarded the Legion of Merit for doing the job well.

Promoted to Deputy Commander-in-Chief of the Pacific Fleet in 1944, Vice-Admiral Towers was given the Distinguished Service Medal for his direction of logistic support in the fiercely fought battles for the island bases in the South Pacific. He helped develop the Navy's tactics for neutralizing the enemy's air and sea defenses in a vast invasion area while a new landing was taking place.

Raised to the full rank of Admiral on November 7, 1945, he was named Commander-in-Chief of the Pacific Fleet in February, 1946. He held this command for a year and then served as Chairman of the General Board, Navy Department, before retiring in December, 1947.

Prior to joining the Flight Safety Foundation in 1953, Admiral Towers had been a Vice-President of Pan American World Airways, Inc.

He is survived by his widow, Anne, of New York, and a son and daughter. Burial was in Arlington National Cemetery.

Joe C. Towle

Joe C. Towle, MIAS, Director of Flying Operations, Lockheed Aircraft Corporation, died April 25 after an operation in a Burbank hospital. He was 49.

Mr. Towle made his first solo flight in 1928. After several years as a pilot with the Byrd-Frost Oil Co. and Fairchild Aerial Surveys, he joined Lockheed in 1939. He piloted a number of planes on their first flights, including the P2V Neptune, the Constitution, and the WV-1 radar plane. He made the first test flight in the P-38A Lightning and did considerable test work on the F-80 Shooting Star and the Constellation. He was in charge of the Lockheed production test pilots, testing of production models, and flight training for customer air lines.

Mr. Towle lived in Newhall, Calif. He is survived by his widow, Evelyn Zarr Towle, and three brothers.

William E. Boeing Honored

William E. Boeing, founder of the Boeing Airplane Company, was honored by Seattle University on April 20 for his "contributions to the strength of our nation in war and peace." He received the University's Economic Statesmanship Award for 1955.

The scroll was presented at a luncheon by Thomas J. Bannan, Chairman of the University's Board of Regents and President of Western Gear Works. Other speakers were Gov. Arthur B. Langlie, of Washington; Mayor Allan Pomeroy, of Seattle; Rear Adm. A. M. Bledsoe, USN; the Very Rev. Albert A. Lemieux, S.J., President of Seattle University; and Paul A. Volpe, Dean of the University's School of Commerce and Finance.

Seattle University's Economic Statesmanship Award for 1955 is presented to William E. Boeing by the university's chairman, Thomas J. Bannan. *Left to right:* Paul A. Volpe, Rear Adm. A. M. Bledsoe, Mr. Bannan, Mr. Boeing, Gov. Arthur B. Langlie, and the Very Rev. Albert A. Lemieux, President of Seattle University.

New Corporate Member

The Aircraft Products Division of Manning, Maxwell & Moore, Inc., Danbury, Conn., has joined the IAS as a Corporate Member. This Division manufactures accessories of an instrument and control nature. Its major field is jet-engine control, with products such as exhaust nozzle actuators, afterburner fuel controls, temperature and speed control amplifiers, inlet guide vane controls, and ram temperature sensers. Some of the instruments manufactured are pressure gages, thermocouples, pressure switches, thrust indicators, and overtemperature switches.

Engineering and final assembly are concentrated in a new 60,000-sq.ft. plant in Danbury. This plant has extensive environmental test equipment and an analog computer facility. Parts are manufactured in quantity at the Stratford, Conn., plant, which has 300,000 sq.ft. of floor space. A small engineering plant in Inglewood, Calif., is devoted almost exclusively to hydraulics research and development. Advanced air-frame power control development is the prime interest in this West Coast operation.

Safety Winners for 1954

In the National Safety Council's contest among aeronautical industries in 1954, Douglas Aircraft Company's Santa Monica plant led 18 companies in the manufacturing division, followed closely by Northrop Aircraft, Inc., and North American Aviation, Inc.

Among concerns manufacturing aircraft parts, Lewis Flight Propulsion Laboratory, NACA, led the Aviation Division of The Oliver Corporation and the Aircraft Division of Hughes Tool Company.

News of Members

▸ **Wellwood E. Beall** (F), Senior Vice-President, Boeing Airplane Company, received a Centennial Award from the College of Engineering, New York University, for "professional achievements and service to the common good." He was graduated from N.Y.U. in 1930.

▸ **George F. Chapline** (F), Vice-President, Fairchild Engine and Airplane Corporation and General Manager, Fairchild Engine Division, sponsored the Society of Automotive Engineers' Aeronautic Production Forum in New York April 21.

▸ **James H. Doolittle** (HF), Vice-President, Shell Oil Company, and Past-President of the IAS, has been awarded the 1954 Gold Medal of the Féderation Aéronautique Internationale for his personal contributions to aviation progress and development. The international civil aviation honor was conferred June 23 at the 50th Anniversary Conference of the FAI in Paris. Mr. Doolittle also was recently chosen President of the Wings Club, New York.

▸ **Hugh L. Dryden** (HF), Director of the National Advisory Committee for Aeronautics, has been elected Home Secretary of the National Academy of Sciences.

Ralph L. Bayless, AFIAS, has moved up to Chief Engineer of Convair's San Diego Division. He joined the company in 1936 after 6 years with the USAF as an aeronautical engineer.

▸ **John F. Floberg** (AM), former Assistant Secretary of the Navy for Air, has been elected a Director of Flight Refueling, Inc.

▸ **Roger Wolfe Kahn** (M), Vice-President, IAS, has been awarded the post's Medal of Merit by Air Service Post 501, American Legion, New York City. In presenting the medal on May 11, Vice-Adm. Charles E. Rosendahl, USN (Ret.) (FIAS), stated it was given in recognition of his work as a test pilot at Grumman Aircraft Engineering Corporation during World War II and since that time.

▸ **Raymond P. Lansing** (AF), Vice-President—Group Executive, Bendix Aviation Corporation, has been chosen sponsor of the Society of Automotive Engineers' 1956 Aeronautic Production Forum.

▸ **Frank N. Piasecki** (F), of Piasecki Helicopter Corporation, has been given honorary membership in Tau Beta Pi in recognition of his contributions to the advancement of rotary-wing aircraft. He joined the New York University chapter on April 23.

▸ **Benjamin F. Ruffner** (AF), Project Engineer, Preliminary Design, Boeing Airplane Company, was cited for "professional achievements and service to the common good" in a Centennial Award from New York University's College of Engineering. He was in the Class of 1929.

▸ **Igor I. Sikorsky** (HF), Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation, has been elected an Honorary Fellow of the Royal Aeronautical Society. He recently received the James Watt International Medal when he delivered the Clayton Lecture before The Institution of Mechanical Engineers in London.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

Major General Victor E. Bertrandias, USAF (Ret.) (AM), Vice-President, Hammond Manufacturing Corporation and its subsidiary, the Air Logistics Corporation, Pasadena, Calif. Formerly, Deputy Inspector General, USAF.

Frank W. Fink, FIAS, has joined Ryan Aeronautical Company as Vice-President and Chief Engineer. He was formerly Chief Engineer of Convair's San Diego Division.

James E. Bevins (TM), Assistant Director of Engineering, Eclipse-Pioneer Division, Bendix Aviation Corporation, Teterboro, N.J. Formerly, Chief Engineer, Utica Division.

Laurence H. Cherry (M), Engineer, Development Department, Aircraft Gas Turbine Division, General Electric Company, Cincinnati, Ohio. Formerly, Engineering Assistant to the Director, Guided Missiles Division, Bureau of Aeronautics, Navy Department, Washington.

John F. Haines (M), Chief Development Engineer, Atomic Energy Department, American Locomotive Company, Schenectady, N.Y. Formerly, Vice-President and Chief Engineer, McCauley Industrial Corporation, Dayton, Ohio.

Robert L. Halfman (M), Associate Professor, Department of Aeronautical Engineering, Massachusetts Institute of

(*Continued on page 56*)

Edwin A. Speakman, AFIAS, has been elected a Vice-President of Fairchild Engine and Airplane Corporation. He continues as General Manager of the Guided Missiles Division, Wyandanch, N.Y.

St. Louis Section's First
Paper Competition

The St. Louis Section in keeping with its policy of promoting aviation in the educational institutions of the Midwest, held its First Annual Student Paper

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AERONAUTICAL ENGINEERING REVIEW—AUGUST, 1954

Minta Martin Aeronautical

Student Fun

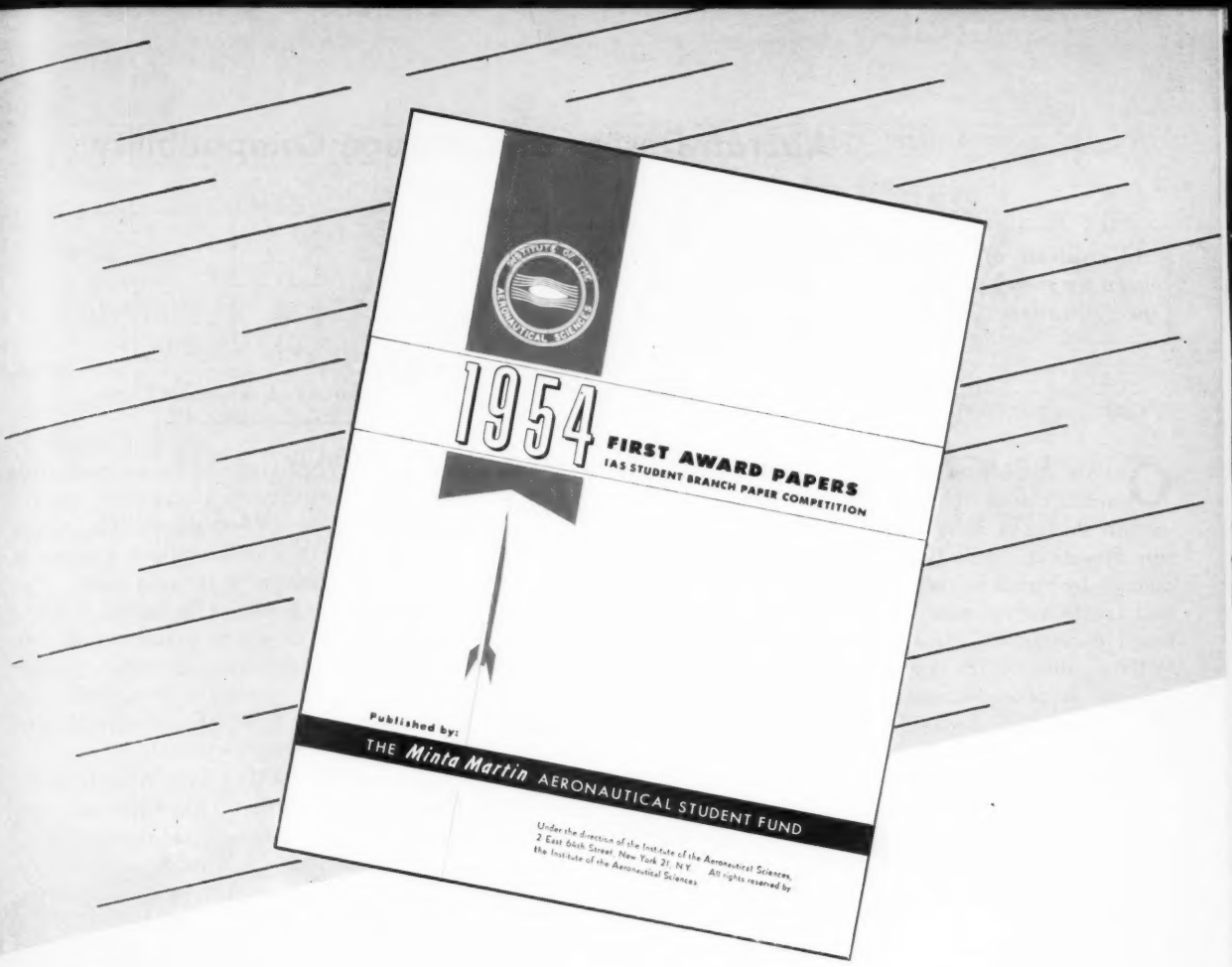
Establishment of the Minta Martin Aeronautical

IAS

AERONAUTICAL ENGINEERING REVIEW—SEPTEMBER, 1954

West Coast IAS Student Branch Conference and
Industry-Faculty Conference

The winners in the undergraduate division of the Los Angeles
Conference of IAS Student Branches are shown
Conference, of IAS Student Branches are shown


1954
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Editorial

One of the most important activities in which the Institute is now engaged is in the area of Student Branch support. We are all very much aware that the life blood of our industry must be constantly renewed from the reservoir of young men of talent who are now in our engineering and technical schools. Until recent years, there appeared to be a comfortable surplus of supply and demand, but industry is now painfully aware that the situation has undergone radical change, and it is facing an annoying present shortage and a critical future shortage of engineering talent in all categories.

The Institute is in a position to do something to combat this dangerous trend. Members will recall that about 3 years ago we initiated a special study of job classifications, educational requirements, and salary range covering engineers in the aviation industry. Our Vocational Guidance Manual has gone through two editions, and the IAS has provided over 50,000 free copies to vocational guidance counselors in high schools and colleges. At present a revision is being contemplated aimed to carry the story directly to potential students.

Also, thanks to the availability of the Minta Martin Aeronautical Student Aid Fund, donated by Glenn L. Martin, we have been able to expand our Student Branch activities everywhere in the United States. Every Section of the Institute has been urged to establish Student Branch committees to support the IAS Student Branch work in its area, and a new impetus has been given to annual regional conferences and student competitions.

Elsewhere in this issue (and also in the May issue) are detailed accounts of the six conferences held this year. Interest and attendance have been high, and plans for next year's programs are already under way. The illustrations on these pages have been selected at random from various conference files to show the general flavor of these meetings.

We urge that each IAS Section, which has not already done so, survey the Student Branches in nearby schools and get to work to assist them as much as possible. Every member who has any ideas for the betterment of our student programs is urged to let us have them. Thomas Meskel, IAS Assistant Secretary, has general charge of the program. Pass along to him any thoughts that occur to you which will help us do a better job in this important area.

S.P.J.

Aircraft Design and Mission Compatibility

An analysis of ultimate operational effectiveness—measured by group performance rather than individual aircraft performance.

Frederick M. Gloeckler*
U.S. Naval Air Development Center

ONE OF THE MAJOR PROBLEMS which confronts the aircraft design planner is to decide what kind of aircraft should be designed for a particular type of future operation. This type of decision has been made difficult by virtue of the many technological advances that create such a wide variety of choices as to confound engineering intuition. A reasonable approach to the solution of this type of problem can be found in the use of practical operations analysis techniques. The purpose of this paper is to illustrate such an analysis and to indicate typical results.

You have all seen advertising slogans such as, "Our aircraft carry a greater pay load faster, higher, and further." Apart from the ambiguity and inconsistency of such a statement, you might well ask, "What are the benefits of greater speeds and altitudes in accomplishing a given mission?" It is well recognized that in a reasonably flexible aircraft design, pay load and range are somewhat interchangeable—that is, you can increase the pay load by reducing the range, and vice versa. However, if for a given mission where a certain cargo has to be carried a specified nonstop distance, a high-speed aircraft must be considerably larger and heavier than one having a moderate speed. Since each larger high-speed aircraft costs more and hence fewer aircraft are available for a given budget, it must be determined whether or not fewer high-speed aircraft are more effective than the greater number of slower aircraft.

Approach to the Problem

In approaching a problem such as previously indicated, it has been found useful to utilize the following component breakdown:

The mission to be accomplished, or the job to be done.

The various ways of doing the job.

How well the job can be done and in what manner.

Fig. 1 indicates in block diagram form the relationship of these components.

Mission

Let us consider a hypothetical problem that is illustrated by Fig. 2 which will indicate the mission to be accomplished.

Presented at the Aircraft Design Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24-27, 1955.

* Acting Director, Air Warfare Research Department.

This problem is that of determining the most effective type of transport aircraft to carry a variety of military goods a nonstop distance of 2,500 miles. The nature of these goods is such that provision for a cargo of 10,000 lbs. and of a certain size is a requirement. Fig. 2 shows the direct route to be under the influence of two enemy territories, each of which contains unknown quantities and types of interceptor aircraft. In considering the mission, it is necessary to consider the entire tactical environment in which our aircraft must operate in the selected future time period.

Now let us examine Fig. 2. Our aircraft are to transport goods from point A some 2,500 miles to point B. As you can see, the enemy occupies regions X and Y on either side of the direct A-B route. The enemy interceptors should have a combat radius of 600 miles; thus, if the direct route is followed, our aircraft will be susceptible to attacks from both sides. However, if our aircraft veer to one side of the direct route, they may be able to avoid the interceptor from one of the two enemy regions. It is assumed that the enemy will have an air-borne early warning system covering the region between X and Y in order to get his interceptors into action in adequate time and to direct the course of the combat.

Ways of Accomplishing the Mission

In this particular problem, the ways of accomplishing the mission will be limited to different types of aircraft. The primary variables will be maximum speed, size (or gross weight), and propulsion type. Since all types of aircraft must be capable of carrying a 10,000-lb. pay load over the 2,500-mile distance, as the design high speed is increased, the gross weight or size must also increase. This is due primarily to the fact that as the speed is increased:

(1) The power plant constitutes a higher percentage of the total aircraft weight.

(2) The entire design configuration is less suited for economical cruising.

Both of these factors are complicated functions of the various interrelated design parameters. Great care must be taken to keep all design estimates compatible with the desired operational period of the future.

Let us examine Fig. 3, which summarizes the results of an extensive preliminary design study for a series of turboprop-powered aircraft. This plot shows the

ANALYTICAL PROCEDURE

FIG. 1.

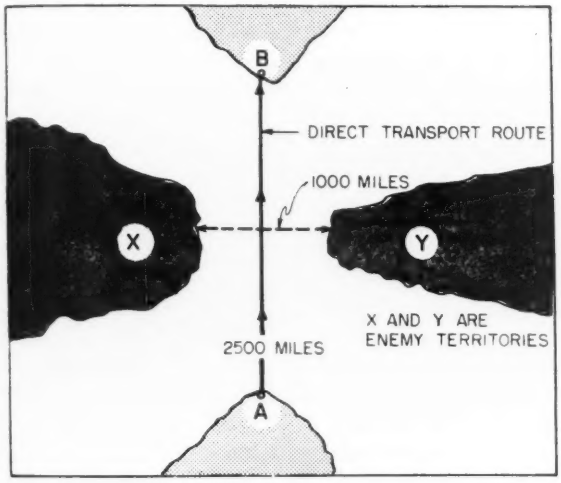


FIG. 2.

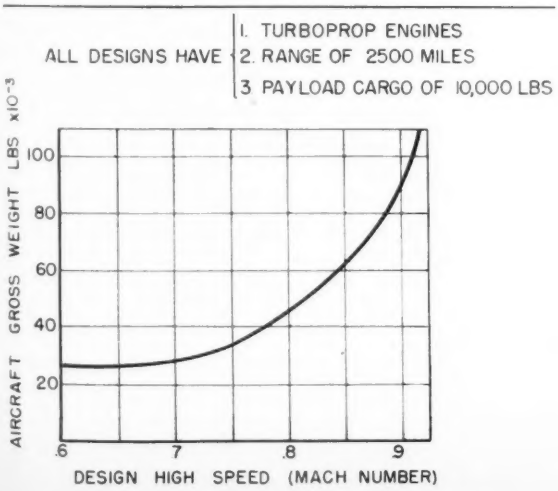
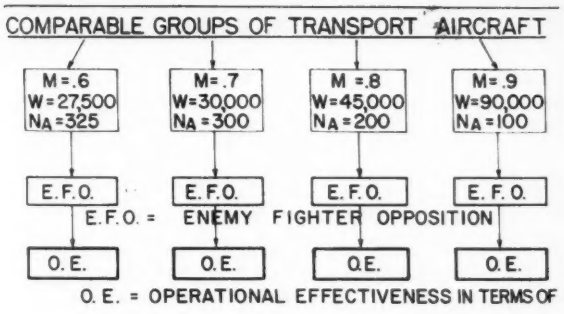


FIG. 3. Effect of design speed on aircraft weight.



- CARGO TONNAGE DELIVERED PER TON OF AIRCRAFT LOST
- CARGO TONNAGE DELIVERED PER AIRCREW LOST
- CARGO TONNAGE DELIVERED IN ONE OPERATION

FIG. 4.

FIGHTER POSITIONING CAPABILITY

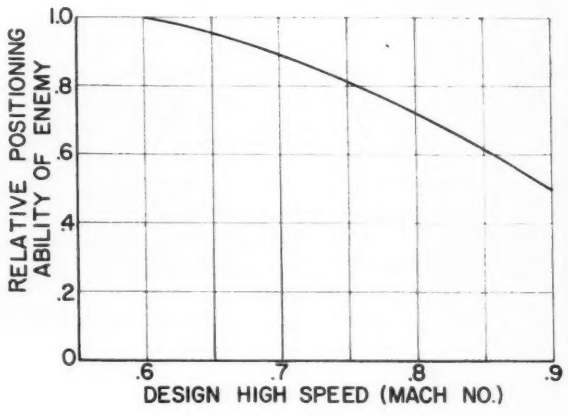


FIG. 5.

ENEMY WEAPON EFFECTIVENESS

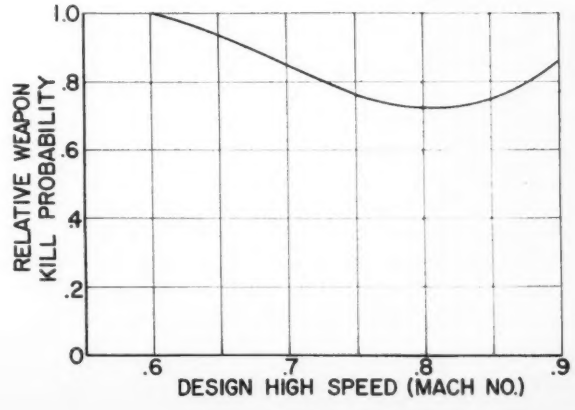


FIG. 6.

GROUP EFFECTIVENESS

	MACH 7. GROUP	MACH 9. GROUP
GROUP SIZE-NUMBER OF AIRCRAFT	300	100
BATTLE LOSSES-NUMBER OF AIRCRAFT	50	28
BATTLE LOSSES-TONS OF AIRCRAFT	750	1260
CARGO TONNAGE DELIVERED	1250	360
CARGO TON. DEL./CREW LOST	25	12.9
CARGO TON. DEL./TON. AIR. LOST	1.67	.29

FIG. 7.

relationship of gross weight and design Mach Number for the turboprop aircraft designs that carry 10,000 lbs. of pay load 2,500 miles. This curve reveals:

(1) The Mach 0.7 design is only slightly heavier than the Mach 0.6 design.

(2) Beyond Mach 0.7, the gross weight increases rapidly as the design Mach Number is increased. The Mach 0.9 design weighs about three times as much as the Mach 0.7 design.

The snowballing of such effects as—sweepback and attending loss of cruise efficiency, increased fuel consumption per pound of aircraft, and increased powerplant size per pound of aircraft—all combine to make the Mach 0.9 aircraft three times the weight of the Mach 0.7 aircraft for the same range and pay load.

A series of turbojet-powered aircraft was also investigated. For the 2,500-mile range under consideration, the turboprop designs were superior over the Mach Number range of 0.6 to 0.9.

THE EFFECTIVENESS OF THE ENTIRE OPERATION

Perhaps the most important aspects of an operations analysis are the determination of the basis for comparison and the determination of appropriate measures of effectiveness. There is a book entitled *How to Lie with Statistics* which shows extremely well how the selection of measures can appear to prove a biased claim. It goes without saying that this course of action must be shunned. Above all, the analyst should avoid preconceived notions about the results in order to preclude subconscious tendencies to prove his point.

In a good many problems, there is no one single measure of effectiveness which is adequate for the purpose; therefore several measures, usually related, may be used. Three measures of effectiveness are used in this problem, as illustrated by Fig. 4.

It would be obviously inappropriate to compare the effectiveness of *one* Mach 0.7 aircraft with *one* Mach 0.9 aircraft, since the Mach 0.9 aircraft is roughly three times the cost of the Mach 0.7 design. Therefore, the concept of comparable groups of aircraft is an essential one. For the sake of simplicity, each comparable group of aircraft is composed of 4,500 tons based on the gross weight. Since gross weight is roughly indicative of aircraft initial cost and operating cost, weight equivalence has been assumed to be cost equivalence. In an actual analysis, a more detailed basis for comparison would be required.

Each of the comparable groups will be exposed to enemy fighter opposition, and the surviving aircraft of each group will deliver their pay load. The effectiveness of the operation is measured as indicated on Fig. 4, where the tonnage of aircraft lost to the enemy is assumed to be indicative of the aircraft replacement cost.

Since it appears inappropriate to express human life as a component of a total dollar cost, the economy of human life is expressed by a separate measure—cargo tonnage delivered per air crew lost.

There will be occasions when the cargo tonnage delivered in one operation is of considerable importance. This comprises the third measure.

In considering the relative ability of our aircraft to survive enemy fighter opposition, a large number of factors must be evaluated, such as susceptibility to enemy early warning, ability of enemy aircraft to attain a suitable position for firing his weapon(s), and effectiveness of the enemy's weapon(s).

The foregoing factors, among others, must be evaluated as well as possible, in some cases on extremely scant knowledge of the enemy. It is essential to cover a wide variety of conditions to ensure adequate treatment of the problem. For example, it might be extremely difficult to predict the enemy's fighter strength in terms of numbers and performance; however, varying the enemy's strength over a reasonable range will indicate the influence of this parameter on the results.

Fig. 5 indicates the arbitrarily assumed ability of one enemy fighter to get into a suitable weapon firing position on one preselected transport aircraft as affected by the speed of the transport aircraft or target. This assumed relationship shows a marked decrease in positioning ability as the target speed is increased.

Fig. 6 indicates an assumed relative effectiveness of the enemy fighter's weapon against one target aircraft as affected by the target's design speed and related size. While generally the fighter's aiming accuracy is reduced by increasing the target's speed, the increased size of the aircraft due to its higher design speed is a strong compensating factor.

Combining the results of Figs. 5 and 6, we can conclude that one enemy fighter has a much higher probability of killing one Mach 0.7 aircraft than of killing one Mach 0.9 aircraft—by a ratio of almost 2:1. This is far from the complete picture. If, against an enemy of certain strength, a group of 300 Mach 0.7 aircraft suffer a loss of 50, the group of 100 Mach 0.9 aircraft would suffer a loss of 28 aircraft. The results are shown in Fig. 7.

Fig. 7 shows the Mach 0.7 aircraft to be markedly superior based on all three measures, this superiority being due entirely to the greater number of smaller, slower, and less expensive aircraft. It further demonstrates an oft-forgotten but well-known principle that whenever there is a budgetary or similar production

limit, increasing individual component performance at the expense of reduced numbers may well degrade the performance or effectiveness of the entire system.

Fig. 8 shows the relative effectiveness of various designs based on the economical utilization of life and material. This plot indicates that economy of life is compatible with economy of material and that designs in the region of Mach 0.7 are reasonably good on both counts under the assumed conditions of this analysis.

Concluding Remarks

In conclusion, it must be stated that the foregoing results are not intended to indicate the superiority of Mach 0.7 transport aircraft, since—for security reasons—this result ensued from the arbitrary assumptions of this hypothetical problem. It is intended that all results presented herein illustrate the following points:

(1) The performance of individual aircraft is not an adequate basis for measuring its worth. It is the group behavior in its operational environment which is of major importance.

(2) The ever-persistent trend toward higher speeds and larger aircraft should not be tacitly accepted as a desirable one. During the preliminary design stages, a thorough operational analysis should be made to ensure that the selected design will be a reasonably effective one.

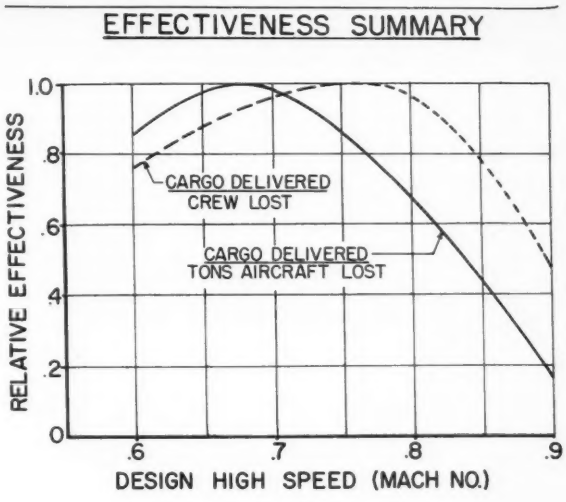


Fig. 8.

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2 East 64th Street, New York 21, N.Y.

A comparative study of afterburner augmentation and hot turbine engines with reference to cruise performance, specific fuel consumption, and net specific thrust.

Before Afterburners

Frank F. Rand, Jr.*
General Electric Company

Symbols

D	=	drag
F_n	=	net thrust
L	=	lift
M	=	Mach Number
P_r	=	compressor pressure ratio
R	=	range, miles
SFC, sfc	=	specific fuel consumption (lb. fuel/hour/lb. thrust)
T	=	temperature, °F.
T_t	=	total temperature, °R.
V	=	velocity, ft./sec.
W_a	=	compressor air
η_c	=	compressor efficiency
η_b	=	burner efficiency
η_f	=	combustion efficiency
h_f	=	fuel heating value (B.t.u./lb.)
η_t	=	turbine efficiency
μ	=	ratio gross weight to empty weight

Introduction

Considerable effort has been expended in the past to select an engine that will develop high thrust with good specific fuel consumption. To meet all possible objectives would require a completely variable engine with either much improved high-temperature materials or cooling system for high-temperature operation. A basic cruise engine could be designed and then the range of operation extended either by adding an afterburner or, as was the case "before afterburners," with a hot turbine design. Good cruise performance could be realized with the basic engine at high subsonic Mach Numbers, and high thrust could be developed with either the afterburner or hot turbine design at supersonic Mach Numbers.

The basic idea of this paper is to develop a good cruise engine and determine the advantages and disadvantages of adding heat to a basic engine in either an afterburner or high-temperature combustor upstream of the turbine. If all variables were constant, the cycle efficiency would be better for the hot turbine engine than for the afterburner engine. The two cycles are shown ideally on a temperature entropy plot (see Fig. 1): 1, 2, 3, 4, 5, 8 hot turbine and 1, 2, 3, 4′, 5′, 7, 8′ afterburner engine. An actual design with realistic efficiencies should be used to arrive at a final comparison of the two configurations.

Merely for purposes of this paper a comparison is made between the afterburner augmentation and the high-temperature turbine version of the basic engine over a range of flight Mach Numbers from 0.5 to 2.0 at altitudes of 20,000 to 80,000 ft.

Basic Engine

Fig. 2 shows a schematic drawing of the basic, afterburner augmentation, and hot turbine engines. The outline shown for the hot turbine engine is the same for the basic cruise engine.

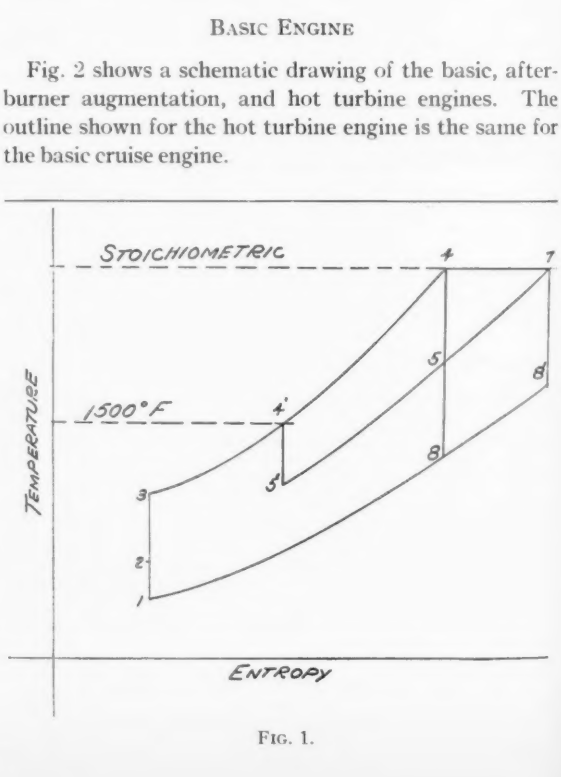

Fig. 1.

Presented at the Flight Propulsion Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Supervisor, Test Vehicle Design & Component Test, Small Aircraft Engine Department.

The author gratefully acknowledges the valuable assistance given by C. W. Smith, George Eric Forsen, and Ted R. Timbie in the preparation of different parts of this paper.

It was decided to develop a basic engine that would give extremely good cruise performance. Using the Breguet range formula $R \cong (V/sfc)\ (L/D)\ \log \mu$, it can be shown that the range is inversely proportional to the *sfc*. A flight speed should be selected which will yield maximum air frame (L/D) and give optimum engine performance. For the design Mach Number and given gross to empty weight ratio, the best range will be secured with relatively low turbine temperatures and high component efficiencies.

Sea-level static calculations were made over a range of pressure ratios of 3 to 8 and turbine temperatures of 1,300° to 1,600°F. (see Fig. 3), and at 40,000 ft. over a range of pressure ratios of 4 to 8 at flight Mach Numbers of 0.85, 1.5, and 1.75 (see Figs. 4 and 5). It is desirable to have component efficiencies as high as possible. The big advantage comes from turbine temperature increase for the range of efficiencies considered. There is a large increase in F_n/W_a in the range of 1,300° to 1,600°F. However, the *sfc* increases to a lesser ratio for the same temperature range with similar component efficiencies.

It was decided to select 40,000 ft. as the design altitude. Referring to the sea-level static curves (see Fig. 3), this would give good thrust at sea level and a specific fuel consumption order of 0.85 for a pressure ratio of 6. Referring to Figs. 4 and 5, for operation at 40,000 ft., the pressure ratio of 6 would result in good performance in both *sfc* and F_n/W_a over the flight Mach Number range of 0.5 to 2.0 and also the potential of good off-design performance over the engine pressure ratio range of 4 to 8.

It was decided to develop the selected pressure ratio with an eight-stage compressor and a two-stage turbine. Fig. 6 presents performance of the basic engine for normal continuous operation at a pressure ratio of about 6 with reasonable component efficiencies and losses. Similar data were calculated at pressure ratios of 4 and 8 with the selected compressor and turbine. No classified engine data were used.

The Afterburner Engine

In order to develop the performance of the basic engine and afterburner, a range of combustion efficiencies as a function of total pressure was selected. Here, security restricted the information that could be used. For the purpose of this paper, it was decided to extend the curve supplied in the American Society of Mechanical Engineers paper, "The Combustion Efficiency Problem of the Turbojet at High Altitude" (54-SA-24), by W. J. Olson, J. Howard Childs, and E. R. Jonash. The curve was arbitrarily extended to the combustion efficiency of 30 per cent at 4.4 lbs. per sq.in. absolute (see Fig. 7). Employing this curve and assuming that the range of momentum loss was comparable to released ram-jet losses of 4 to 12 per cent enabled us to generate the basic performance data required to compare the afterburner configuration to the hot turbine engine.

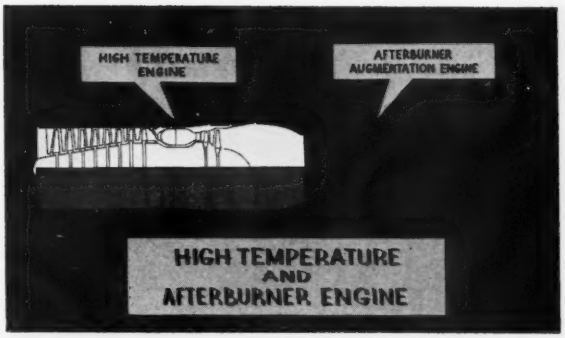

Fig. 2.

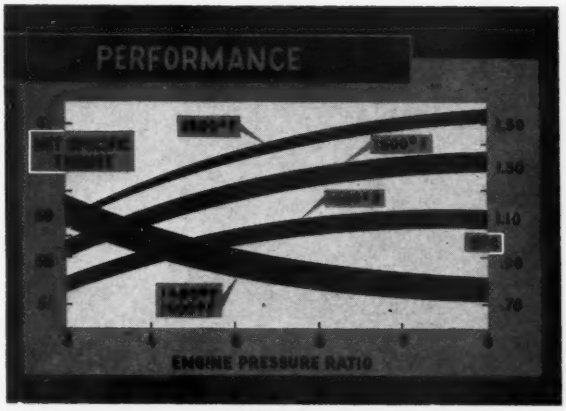

Fig. 3.

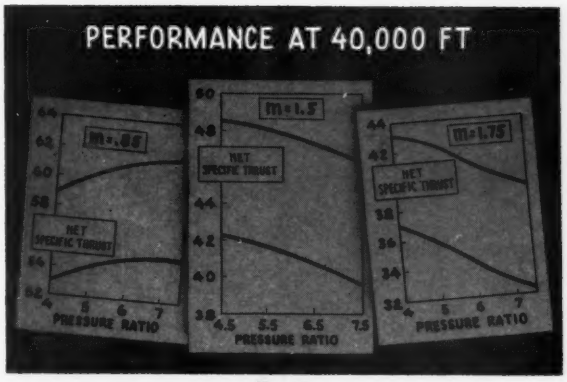

Fig. 4.

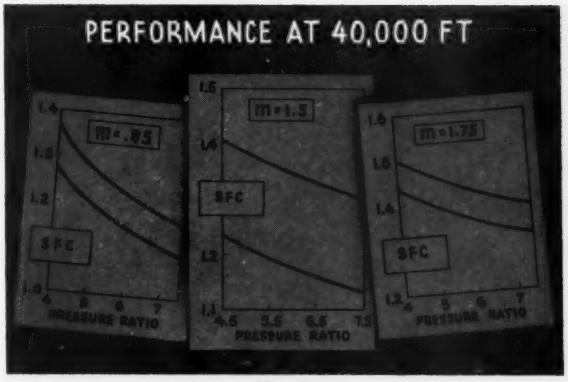

Fig. 5.

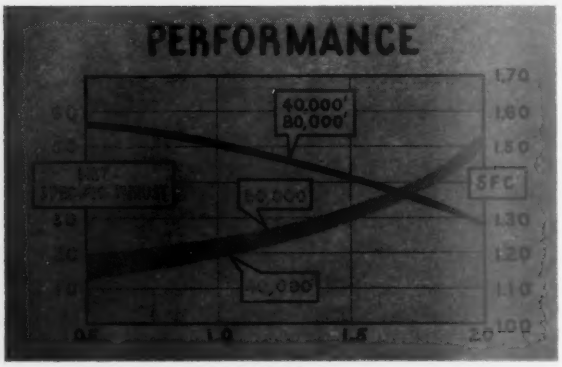

FIG. 6.

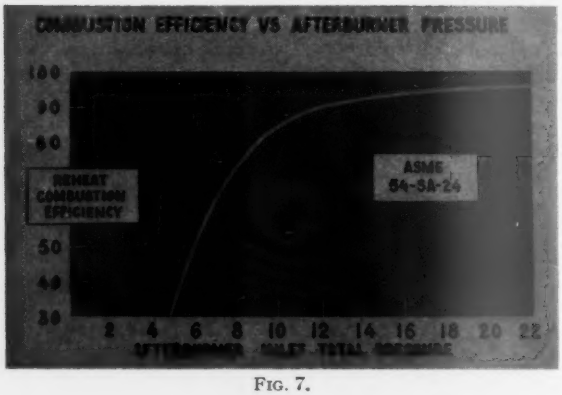

FIG. 7.

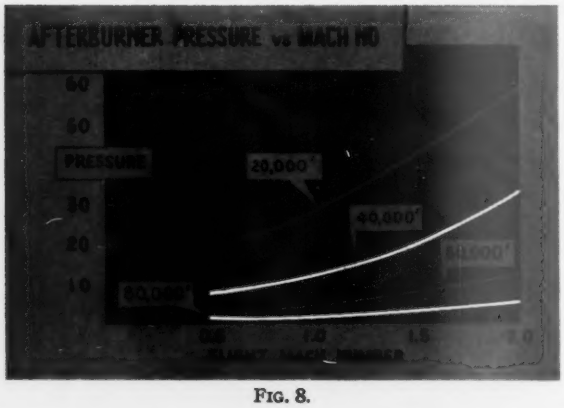

FIG. 8.

FIG. 9. Upper curve, hot turbojet; lower curve, afterburner.

The total pressure downstream of the turbine was taken from the basic engine data listed above. These data are summarized in Fig. 8 for pressure ratio of 6. In order to compare the afterburner version of the basic engine to the hot turbine engine and reduce the number of calculations, it was decided to use the design pressure ratio of 6 over the flight Mach Number range of 0.5 to 2.0 and the altitude range.

It can be seen by referring to Figs. 7 and 8 that the combustion efficiency is extremely low at the higher altitudes below flight Mach Numbers of about 1.0. Increasing the pressure ratio to 8 would improve this picture slightly; however, the same general trend would exist. Calculations were performed at an engine pressure ratio of 6 at stoichiometric temperatures for the lbs. per sq.in. absolute given for the basic engine as shown in Fig. 8. An 8 per cent afterburner loss and 3 per cent duct loss were used in all afterburner calculations.

It was decided, because of security limits, that realistic percentages of air for cooling could not be employed. Therefore, the two configurations were compared with no cooling. In other words, the data, as supplied, point out the limits that are possible for the two proposed configurations of the basic cruise engine. Final data are presented in Figs. 9 and 10 at various altitudes. Comparison of the afterburner engine and hot turbine engine data is summarized in the conclusions.

Hot Turbine Engine

The same basic engine efficiencies and stoichiometric temperatures were used to calculate the performance for the hot turbine engine as employed in the afterburner engine. The combustion temperatures could have been increased for the hot turbine engine because of the increased total pressure in the combustor located upstream of the turbine. This increase would increase the F_n/W_a and would also increase the *sfc*, but to a lesser extent. For comparative purposes, it was decided to use the temperatures employed in the afterburner and a range of combustion efficiency associated with the normal combustor design. This made the comparison more in favor of the afterburner version than would actually be the case.

As in the afterburner configuration, no cooling was employed in the calculations. These data should be considered as limit information based on the assumptions listed in the paper. The data for the hot turbine engine are also summarized in Figs. 9 and 10. Comparison of the afterburner and hot turbine engines data is summarized in the conclusions.

Conclusions

(1) Good cruise performance may be developed for the selected basic engine with a turbine temperature of 1,500° to 1,800° F. over the pressure ratio range of 4 to 8 at sea level and upper altitudes.

(2) In comparing the performance (F_n/W_a and *sfc*) for the hot turbine engine and the afterburner engine

(see Figs. 9 and 10) over a range of altitudes, the hot turbine engine always looks better in *sfc*.

(3) At altitude the net specific thrust for the afterburner and hot turbine engine tend to approach each other at a flight Mach Number about 2.0. If the turbine stoichiometric temperatures had been increased to the limit possible because of the increased burner total pressure in the hot turbine engine, this convergence would have taken place at a somewhat higher flight Mach Number.

(4) Comparison (see Figs. 9 and 10) shows that the hot turbojet engine will operate at higher altitudes in all cases than will the afterburner version. For example, the afterburner will not operate at higher altitudes except at extremely high rates of fuel flow because of the very low combustion efficiency and other losses assumed in the paper.

(5) Comparison of the afterburner and hot turbine versions shows that the hot turbine engine would operate at lower flight Mach Numbers at altitudes above 40,000.

(6) Consideration must be given in the design of a new engine to the time required to develop new materials and methods of cooling. In other words, to develop a new high thrust engine as soon as possible for operation at stoichiometric combustion temperatures, the afterburner version still offers more immediate potential for success.

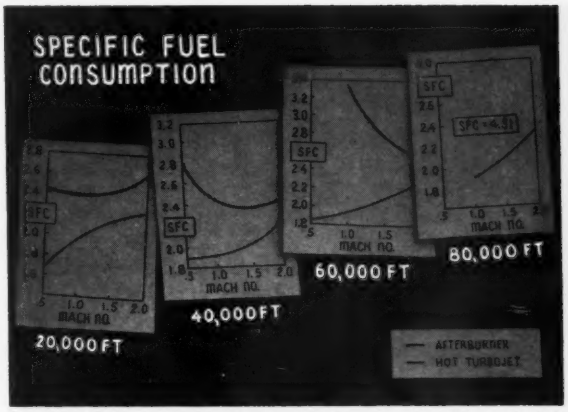

FIG. 10. Upper curve, afterburner; lower curve, hot turbojet.

(7) Mechanical limits at elevated temperatures—i.e., corrosion, stress rupture, and creep—will limit the design of high-temperature machinery for some time, but, because of the possible gain as shown in Figs. 9 and 10, perhaps more effort should be expended in the high turbine temperature direction to improve the design techniques, metallurgy, and cooling systems.

(8) Based on these data at flight Mach Numbers below 2.0, it appears that much more effort should be expended to increase the turbine temperature of new engine designs either with or without cooling in preference to augmentation development.

IAS Twenty-Fourth Annual Meeting

Hotel Sheraton-Astor, New York City, January 23–27, 1956

The Meetings Committee plans to schedule sessions on Aerodynamics, Aeroelasticity, Design, Electronics, Flight Propulsion, Instruments, Rotating Wing Aircraft, Safety in Flight, Structures, etc.

Members or organizations wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 1, 1955.

The Newest Instruments for Astronomical Navigation

A description of the photoelectric sextant, a system planned to perform automatically the functions of sighting, averaging, and presenting celestial reference data on a single control panel.

Victor E. Carbonara*
Kollsman Instrument Corporation

HIGH-ALTITUDE FLYING has brought great prominence to the role of astronomical navigation in long-range flights, since overcast skies are no longer an obstacle to its employ.

At the same time, however, space limitations and the reduction of the crew on aircraft capable of performing long-range flights overseas have changed materially the requirements of form and performance of the necessary instruments.

It was not long ago that, when thinking of long overseas flights, one would invariably connect them with extremely large aircraft having a large crew and ample space available to the navigator, in which case a modern periscopic sextant, capable of furnishing accurate position and celestial directional reference data, was fully adequate.

But astronomical navigation is now being practiced even in fighter bombers traveling at great rates of speed where a lone pilot has to perform the duties of the navigator, among others. With the assistance of a good automatic pilot, it is quite possible for the pilot to make astronomical observations and, by relating them to precomputed data, determine his position with a surprising accuracy. A seriously limiting factor is that the celestial objects above the semicircle of horizon astern of the aircraft cannot be observed, and also that when performing observations with a hand-held instrument one must take into account the refraction errors of the transparent canopy.

In other aircraft, such as the B-47, there are serious problems of installation which also limit the usefulness of the periscopic sextant in that observations cannot be made in every direction.

The suggestion has been made to make a panoramic instrument out of the periscopic sextant. The word "panoramic" defines an instrument in which the direction of the eyepiece can be changed at will in relation to the line of sight of the instrument so that the eyepiece could be held stationary while the periscope can explore around 360°.

The three units: indicator, sextant, and amplifier.

Optically such an arrangement is possible, and it is in fact in common usage on many sighting instruments. The trouble with the sextant is that the simultaneous manual intervention to keep the bubble reference more or less in the center of the field, while at the same time maintaining the observed celestial object in coincidence with the bubble reference, becomes extremely complicated if a panoramic type of eyepiece is adopted.

Operating a sextant of the normal type—that is, a sextant where the direction of the eyepiece is oriented in the same plane as the line of sight of the instrument—requires a type of skill comparable to wing shooting. But, if a panoramic eyepiece system is introduced, the skill requirements rise altogether to those of trick shooting, in that the muscular response to correct a given condition of misalignment of the bubble reference and of the celestial object must change with the changing of the direction of the eyepiece to the observing line of sight.

In some cases, there is also the problem of having to pierce a transparent canopy to accommodate the mount of the sextant, an operation that seems highly undesirable and to be avoided and altogether impossible if the canopy is to be retractable.

A great deal of work has been done in the past years in connection with our research toward completely automatic means of navigation for pilotless aircraft. In seeking a solution to the limitations imposed by condi-

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* President and General Manager.

tions such as those mentioned before, we found that the automatic star-tracking devices in a simplified form—requiring manual presetting so as to limit weight and encumbrance to a minimum—seemed to offer the best answer.

For the greatest simplicity, the operations of bubble-reference centering and that of celestial object collimation could be made separately, one function being made automatic and the other manual. But this would still leave us with the problem of the hole in the canopy and would result in only an intermediate compromise that, while it might prove desirable in special instances, would not solve all of our problems at once, nor would it effectively simplify and render more rapid and secure the obtaining of celestial reference data for navigation.

Therefore, it was thought best to go the whole distance and provide an automatic instrument that could be installed remotely, operate automatically, after manual presetting from a control panel, and perform by itself the operations of sighting, averaging, and presenting altitude and azimuth data on the same control panel—the latter data being presented as true azimuth, true heading, or relative bearing, according to requirements.

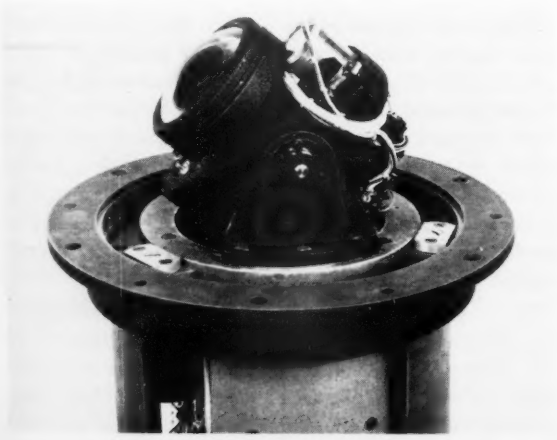
The first version of such an instrument is now ready and will serve as point of departure for those simplifications that might appear possible and desirable during service test; it is not, therefore, to be considered as the last answer but rather as an engineering tool with which to find a still better answer.

General Description of the System

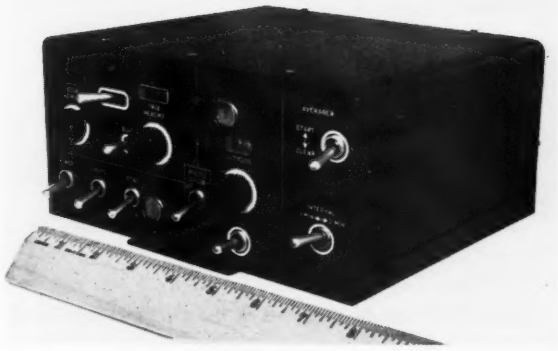
The photoelectric sextant consists of three units—the sextant, the indicator, and the unavoidable amplifier.

Sextant

The function of the sextant is that of establishing the relationship of direction between a celestial object and an artificial horizon and also the angular relationship between the vertical plane containing the celestial object and that containing the fore and aft axis of the aircraft. The automatic and continuous determination of these three directions results in the measurement of the altitude of the celestial object for the determination of a line of position and of the relative bearing of the same object from which to obtain heading information.



Detail of the sextant scanning telescope.



The indicator.

The tracking of the celestial object—be it a star, a planet, or the sun—is performed by a photosensitive telescope mounted with two axes of freedom in altitude and azimuth. The horizontal is provided by a bubble-restoring servo system mounted on and rotating with the azimuth supports of the sextant. A similar bubble servo system at right angles to the first measures the cross tilt of the tracking platform with reference to the horizontal under the star. This feature provides for automatic correction of altitude and azimuth values for platform tilt and eliminates the requirements for a universal mount.

In the absence of a star signal, the system is held in a stand-by mode that causes the sextant to position itself in accordance with the star altitude and azimuth data appearing at the counters of the indicator. The horizontal servo system serves to correct the telescope orientation for any unlevelness of the aircraft. A star-search action is also introduced by mechanisms in the indicator and amplifier. Thus, the telescope will search out a rectangular patch of sky centered on the preset altazimuth data.

The search is performed as a right-left sweep at several steps in elevation and covers an angular area approximately 7° wide by 5° high. Recognition of a star is based on the amplitude of its carrier signal. The level of recognition is set to reject stars of weaker than second magnitude. Acceptance of a star switches the system to the tracking mode, under which operation the sextant azimuth and elevation angles are repeated at the indicator by the follow-up servos.

Indicator

The indicator is provided with means for averaging the continuous star-altitude measure of the sextant and displaying the result on a counter. The measured relative bearing is added at the indicator to the preset star azimuth to provide true heading upon a counter. The panel contains all controls necessary for the operation of the system and is the only unit to which the operator must have access.

Amplifier

The operation of both the sextant and indicator units is primarily electromechanical with controls that are powered by individual amplifiers in the amplifier unit. This unit also houses a star-tracking amplifier and star-detection circuits. Most of the circuitry is mounted on a pair of hinged sections that can be swung out to gain access to all tie points.

Operation of the System

The sextant can be oriented in the approximate direction of the object to be observed by manual presetting of approximate values of altitude and relative bearing on the indicator panel. Automatic search action is then generated in the amplifier to achieve the acquisition of the star.

The aircraft should be in straight and level flight when taking celestial data with this or any other sextant. As in normal procedures for celestial navigation, measures of star altitude are taken consecutively on two or more stars. Since the photoelectric sextant tracks the star automatically, its alignment with the same star will be retained, if desired, during a change in course and used for the final determination of accurate heading.

The actual procedure for acquiring a celestial body and measuring its altitude and azimuth is outlined by the following check list:

(a) Turn power switch *on*. Warmup time is 20 sec.

(b) Throw *sun-star* switch to appropriate setting. When set in the *star* position, the switch removes a sun filter from the optical path and permits tracking on stars and planets. (As a protective measure, the sun filter is automatically thrown in when the system is shut down or first turned on.)

(c) Set in the approximate value (± $1^1/_2$°) of star altitude on the *altitude* counter, using appropriate slue switch and displacement knob.

(d) Set in the approximate values (± $1^1/_2$°) of star azimuth and true heading on the respective counters, using the *azimuth slue* switch and appropriate displacement knobs.

(e) Turn the *photo-volts* switch *on*. The phototube in the sextant is then energized and star-search action becomes effective.

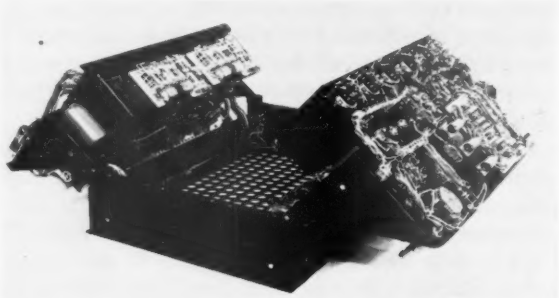
(f) Illumination of the "T" light on the indicator panel indicates the commencement of star tracking. Loss of the star will extinguish the light.

(g) Throw *interval* switch to desired time interval over which the altitude averager is to operate.

(h) Throw *averager* switch to *start* position, and log the time at the instant of switching.

(i) Termination of the averaging period is indicated by illumination of the "R" (or "read") light. Log the average value of altitude being held on the *altitude* counter, then throw the averager switch to *clear*. The logged value of altitude applies to the time obtained by adding half the interval period to the logged time.

(j) To obtain a second average on the same star, repeat steps (h) and (i).



The amplifier. It has been designed in two hinged sections so as to provide easy access to all tie points.

(k) To obtain true heading, throw the transfer toggle (located between the two azimuth counters) to *true heading* and set in exact star azimuth by means of the *star azimuth* displacement knob. Read the *true heading* counter.

(l) To obtain star azimuth, throw the transfer toggle to *star azimuth* and set in true heading by means of *true heading* displacement knob. Read the *star azimuth* counter.

(m) To select another star, throw *photo-volts* switch *off* and repeat steps (c) through (f).

The operator may voluntarily terminate the "read" period by returning the averager switch to its "clear" position.

The measure of star altitude developed at the sextant must be corrected for cross tilt and averaged before an accurate value is obtained. Both of these operations have been incorporated as supplements to the normal function of the altitude follow-up servo in the indicator.

When the azimuth axis of the sextant is controlled by a star signal, a 1:1 synchro on the axis transmits to the indicator the resulting relative bearing of the star with respect to the longitudinal axis of the aircraft. Although the attitude of the aircraft may tilt the azimuth axis in any direction, only the component of cross tilt—i.e., tilt about the azimuth line to the star—affects the relative bearing sufficiently to require compensation. An adequately approximate compensation is obtained from the horizontal servo system.

The simple additive relationship that exists between star bearing, star azimuth, and true heading is maintained by a differential in the azimuth follow-up system. A mechanical selector switch, located on the face of the indicator between the two azimuth counters, determines which of the two counters is held and which is free to rotate. Thus, during tracking, the true heading will be indicated when the correct star azimuth has been set, as one of the results of having determined the aircraft position by means of the sextant.

The star telescope and its photoelectric scanning system are housed as one compact assembly. Light from a star, planet, or the sun is collected by a lens of slightly over 2-in. effective aperture. Light from a star is first interrupted by a semicircular opaque shutter centered on and rotating in a plane immediately ahead of the

image plane. A second interruption or modulation of the starlight is effected by the passage of the opaque radial spokes of a tone wheel across the image plane. The width of the eclipsing spokes of the tone wheel is such as will modulate the image of a star and, to a sufficient extent, that of the sun. No modulation will occur instead on other luminous objects such as aurora phenomena or clouds illuminated by the moon, etc.—all this being essential for star recognition and acquisition.

Tentative Performance Specifications

(A) Sextant Accuracies

The static tracking error of either the elevation or azimuth axis is less than 0.5 min. of arc. The corresponding dynamic tracking error is less than 2.0 min. of arc at rates of less than 10° per sec.

The in-line and cross-tilt servo static errors are each less than 1.0 min. of arc. The corresponding dynamic errors are effectively canceled by subsequent averager action.

(B) Indicator Accuracies

The static accuracy of the altitude indication of a star tracked by the sextant, when subjected to large in-line and cross tilts of ±6° each, is approximately 1.5 min. of arc. The static accuracy of the azimuth indication under the same conditions is approximately 0.5°. (The tracking of high-altitude stars with tilts near the limits of the compensation system may possibly incur a greater error.)

The dynamic accuracy of the altitude indication when the sextant is subjected both to the tilts and accelerations of straight and level flight is to be ascertained by flight tests. Under normal flight conditions, the individual altitude readings are expected to be accurate to within ±6 min. of arc. A running fix resulting from a succession of several star shots is expected to be accurate within 3 miles 90 per cent of the time.

(C) Limits of Operation

Tracking Angles—The optical-mechanical arrangement of the sextant permits stars to be scanned over a range of elevation from 0° to 90° with respect to the mounting flange of the sextant. The practical upper limit for tracking action is fixed at about 80° by the proximity of the azimuth-restoring axis to the line of sight to the star. (Parallelism of the azimuth and optical axes reduces a simple two degree of freedom tracker to one of one degree of freedom.) The lower limit for tracking is fixed by the aircraft's attitude. For a perfectly horizontal sextant mounting, a star at 12° altitude will still be viewed by the full telescope objective. When, however, the latter is pointed at the horizon, 89 per cent of this objective is effective. Tracking in azimuth is unimpeded throughout a full 360° revolution.

From the general characteristics of the system as set forth before, it may be postulated that some sacrifice in the dimensions and weight of the instruments was accepted for the sake of using second-magnitude stars as navigational stars.

The seafarer, with all his navigation by the stars, has almost never bothered with stars of second magnitude, and one might wonder why the aviator, who has generally at his disposal so much more clear sky than the seafarer, would want to bother with them.

The seafarer, who employs the usual mariner's sextant, makes his observations against the sea horizon, for which he must have some twilight. As a consequence, he does not use second-magnitude stars because during twilight he cannot see them.

The aviator cannot use the sea horizon but must avail himself of artificial means to substitute it, and, consequently, he can, if he so wishes, use second-magnitude stars.

Of all the second-magnitude stars, the one that is really almost indispensable is Polaris, which in the northern hemisphere gives us quickly, and almost without any calculations, an extremely good directional reference and a position line in latitude. In these terms, Polaris is so useful that it merits the sacrifice in dimension and weight of the instruments so that advantage may be taken of its peculiar properties.

Star-Data Computer—As a companion piece of apparatus to the automatic sextant, another is coming into being which will add immensely to the usefulness of the first.

This is a star-data computer, which is a mechanism for the solution of the spherical triangle.

There is nothing fundamentally new about mechanisms of this kind. The merits of one against the other lie primarily on the precision of their execution and on the cleverness of design whereby the resulting package may be smaller and lighter without sacrifice of accuracy. But, in substance, they are mechanical analogs of the celestial sphere from which the desired measurements are obtained, doing away with the necessity for trigonometric computation and line of position plotting.

The presence of this companion to the sextant offers some new possibilities in the complete mechanization of the solution of the astronomical navigation problem. The mechanisms in question use as input data the latitude and longitude of the observer and the declination and Greenwich hour angle of the celestial object and give as output the azimuth and altitude of the celestial object. This would be their normal function in the reduction of celestial observations following the usual practice. But it can be observed that if the input data are uniquely related to output, some of the procedures could be reversed—for instance, with input of latitude, altitude, Greenwich hour angle, and declination, one would extract longitude as an answer.

Now, if Polaris because of its usefulness has committed us to building a larger and heavier instrument than we would have had to have if we were interested only in the classical navigational stars of the seafarer, we should derive from it the greatest possible advantage in

(*Continued on page 54*)

An investigation of the theory and experimental results of a device designed to improve airplane take-off and landing performance.

Canted Adjustable End Plates for the Control of Drag*

Harry R. Clements†

Cessna Aircraft Company and the University of Wichita

Introduction

Developments in the fields of boundary-layer and circulation control have made lift coefficients available which were once considered an impossibility. These high lift coefficients are in some cases impractical because of the high induced drag associated with them on finite wings. This is particularly true for the take-off, where this drag reduces performance.

Induced drag can be reduced by increasing the wing aspect ratio or using fixed-wing end plates. These have the unfortunate characteristics of reducing drag for the landing and increasing the landing distance.

It is seen that use could be found for a device that could provide control over drag during the various phases of airplane flight.

The idea was conceived of utilizing end plates whose deflection about a vertical axis could be adjusted so that they would be canted to the direction of free-stream flow. These plates were given the name Canted Adjustable End Plates, and they will be referred to by the abbreviation CAEP throughout the remainder of this paper.

The results of an analytic and theoretical investigation[1] appeared sufficiently promising to warrant experimental verification. The subsequent wind-tunnel investigation is described herein.

Theory

Perfect fluid end-plate theory appearing in the literature[2] shows early investigators to be principally concerned with configurations of minimum drag. The theory consists of defining the force distribution and induced drag of systems with various heights of end plate. To obtain minimum drag, lift forces of a given distribution must exist on the end plates themselves.

An attempt to obtain this force distribution was made in this investigation: The end plates are deflected about a vertical axis so as to have an angle of attack with respect to the relative wind. The portion of the end plate above the wing is deflected to give a reduced pressure on the inboard side of the plate, and the portion below the wing is deflected to give an increased pressure on the inboard side. In this way the force distribution of the wing is extended. The vortex flow of the wing tip is replaced by the vortex flow of the plates, or, in effect, the wing aspect ratio is increased.

If, on the other hand, an increase in drag is desired, the end plates are deflected in a manner opposite that described above. The end plates will not supplement the wing lift distribution. The induced drag will not be reduced and will perhaps be increased because of a more rapidly diminishing lift distribution in the region of the end plates.

As an alternate method, trailing-edge flaps are provided on the end plates, and they are deflected to obtain the desired pressure distribution and resulting vortex flow. This was considered because of the chordwise distribution of lift existing with the wing flap deflected. An attempt to duplicate this distribution on the end plate would tend to reduce cross flow.

Also to be considered is the profile drag of the device. It will add to the lowered drag of the take-off configuration but will help greatly in the landing configuration. For high-speed configurations, where induced drag is small, the added profile drag will be undesirable, but this would be made a minimum by adjusting the plates to be streamlined to the flow.

Test Equipment and Conditions

Wind Tunnel and Accessories

The experimental investigation was carried out in the University of Wichita's 4-ft. wind tunnel. Force measurements were taken on the tunnel's automatic electric beam balance system. For flow visualization a tuft grid was mounted two chord lengths downstream of the model trailing edge. The grid was photographed from a position 23 ft. farther downstream.

The Model

The basic wing model had a Clark Y airfoil section and had no taper in plan form or thickness. The wing had neither twist nor dihedral. It was equipped with

* This work was sponsored jointly by Cessna Aircraft Company and the University of Wichita Aeronautical Engineering Department.

† Section Head, Aerodynamics, and Graduate Student, respectively.

FIG. 1. Bottom-front view of model.

a full span slot and a 30 per cent chord slotted flap. A wing flap deflection of 50° was used for all tests, and any further reference to flaps will mean end-plate flap.

The end plates were constructed in two separate pieces designed to fit below or above the basic wing. An NACA 0012 airfoil section was used on the end plates, and they were made with a 30 per cent chord plain trailing-edge flap. The end plates were attached to the wing by bolts that also served as the pivoting axis for end-plate deflection.

The chord of the end plate and wing were each 5.25 in. The aspect ratio of the wing was 5, and the overall height of the plates was 20 per cent of the wing span (see Fig. 1).

For the photographic tests, the model was mounted asymmetrically in the tunnel so that one tip would be plainly visible near the center of the tuft grid.

To simplify discussion, a nomenclature has been devised to describe the CAEP configurations, and it will be used in the following sections. The end-plate or flap deflections are designated according to their intended results on drag—that is, + for increase drag and − for decrease. The + designation indicates that the trailing edge of the end plate or flap on the upper wing surface was deflected inboard, and the trailing edge of the end plate or flap on the lower wing surface was deflected outboard. For the − designation all trailing-edge positions were opposite to this (Fig. 2). The plate position is noted by the first number in any description, and the degree of deflection was the same for all adjustable components.

Test Conditions

The force tests were run at a constant tunnel dynamic pressure of 4.7 in. of water. With this dynamic pressure, the test Reynolds Number based on the model wing chord was approximately 350,000. The photographic tests were run at a tunnel dynamic pressure of 0.5 in. of water.

TEST RESULTS

General

Several values of end-plate and flap deflection were investigated. They were not tested in combination since this did not seem practical for full-scale application. The early force test showed these facts:

(1) The amount of end-plate or flap deflection required to reduce drag is limited by the increase in profile drag of the deflected control.

(2) Deflection of the entire end plate is more beneficial for reducing drag than is flap deflection. This is explained by the fact that production of a given pressure differential is obtained with less profile drag with total surface deflection.

(3) The amount of end-plate or flap deflection required to increase drag is limited by the decrease in lift coefficient produced by the adverse pressure distribution of this deflection.

(4) Deflection of the end-plate flap is more beneficial for increasing drag, as it causes less loss in lift for a given drag increment.

The following deflections were found to give best results, and they were used for the photographic tests, along with the standard configurations of the plain wing and the neutral end plate:

Intent	End-Plate Deflection	End-Plate Flap Deflection
Decrease drag	−5°	−15°
Increase drag	+15°	+30°

Combining the above table with preceding statements, we see that the optimum decrease drag, or take-off, configuration is with 5° end-plate deflection, and the optimum increase drag, or landing, configuration is with 30° of flap deflection.

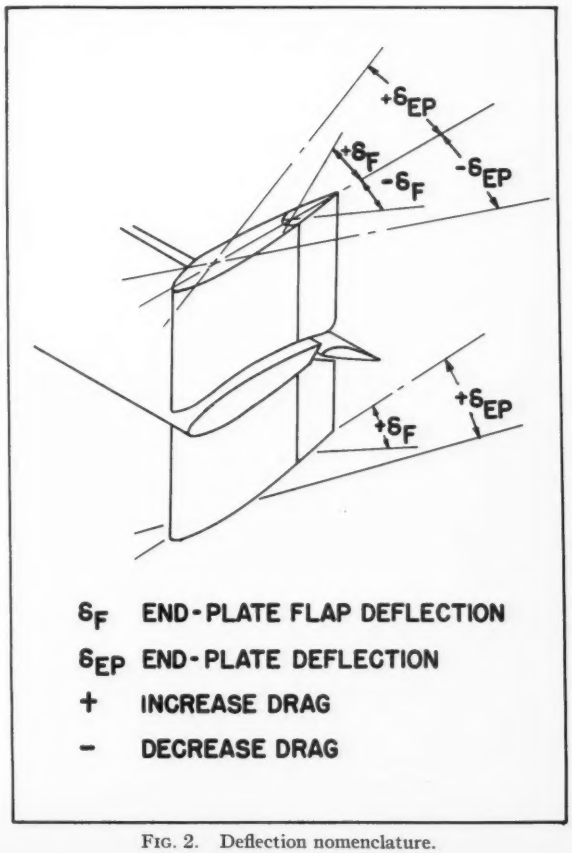


FIG. 2. Deflection nomenclature.

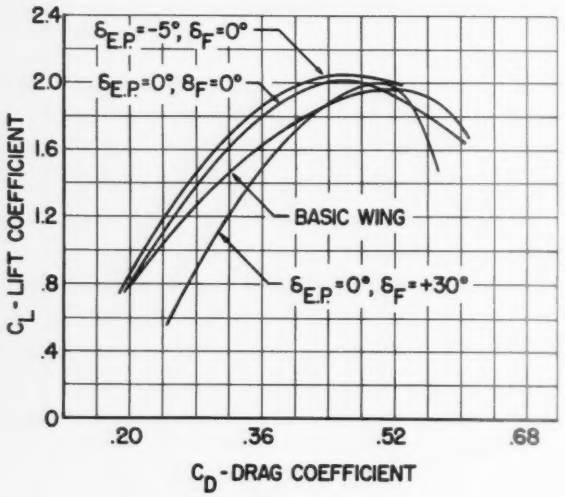


FIG. 3. Summary drag curves.

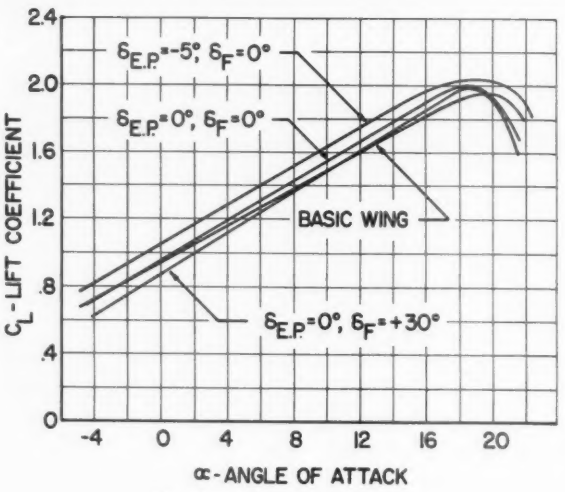


FIG. 4. Summary lift curves.

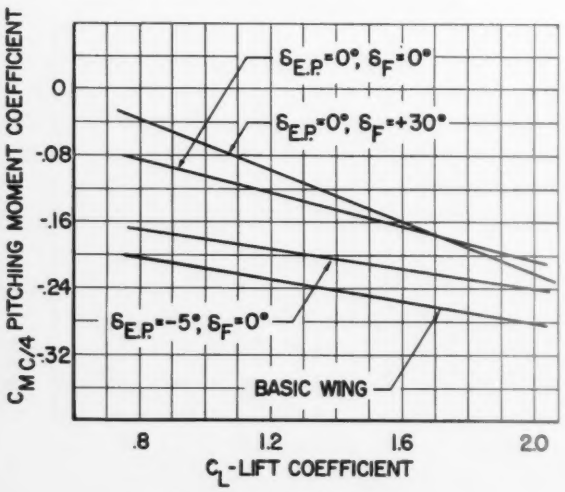


FIG. 5. Summary stability curves.

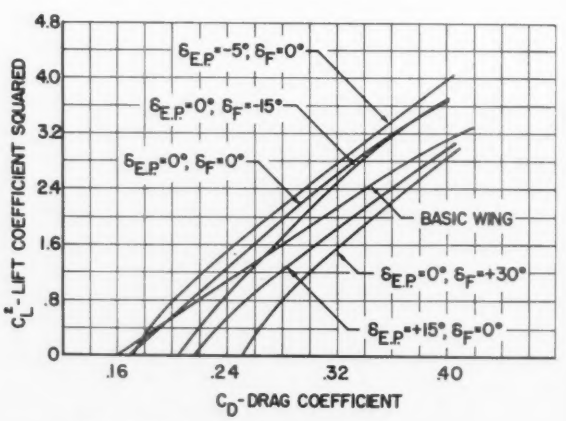


FIG. 6. C_L^2 vs. C_D curves, six configurations.

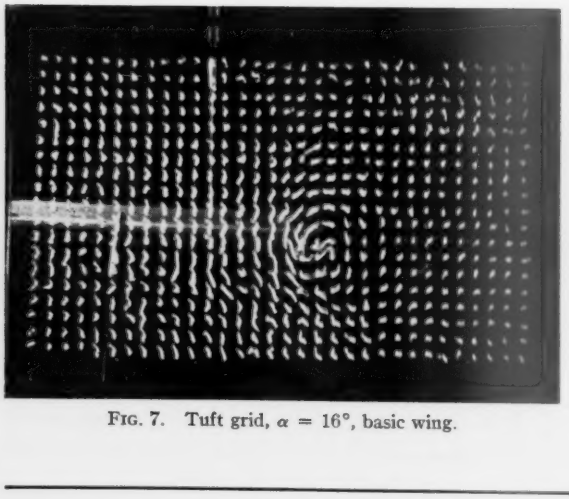


FIG. 7. Tuft grid, $\alpha = 16°$, basic wing.

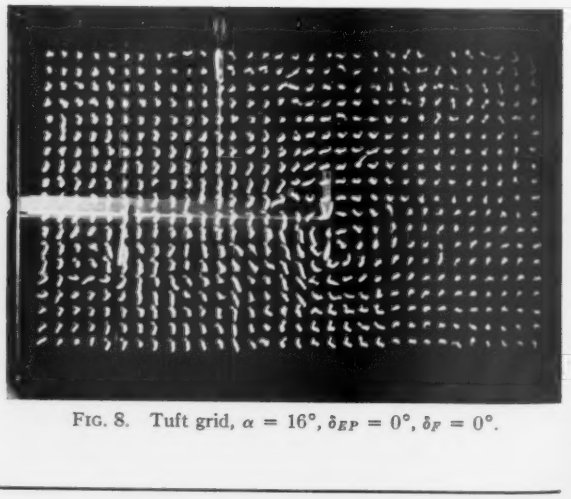


FIG. 8. Tuft grid, $\alpha = 16°$, $\delta_{EP} = 0°$, $\delta_F = 0°$.

TABLE 1

Configuration	C_L	C_D	α	C_M	dC_M/dC_L
Wing alone	1.4	0.308	8.2	−0.246	−0.068
End plate and end-plate flap neutral	1.4	0.284	7.4	−0.149	−0.101
End plate deflected −5°, end-plate flap neutral	1.4	0.269	6.0	−0.205	−0.060
End plate neutral, end-plate flap at +30°	1.4	0.345	8.3	−0.128	−0.148

These results lead to the thought of a fixed end-plate angle to reduce drag, with a flap to be deflected to increase drag. The only objection to this would be the added profile drag in the high-speed configuration.

Final Configurations

The force test results at a given lift coefficient are tabulated in Table 1 for the optimum increase and decrease drag configurations and the standard configurations.

The comparative drag polars and lift curves are shown in Figs. 3 and 4. It is to be noted that there is a lift coefficient for which the CAEP deflection gives a maximum reduction of drag. At other C_L's, the two lift distributions do not coincide, and induced drag is not a minimum. At a C_L of 1.9 the drag with end plate deflected is 19.5 per cent less than the wing alone and 4 per cent less than the drag with a neutral end plate.

It is found that the greatest increase drag increments occur at low lift coefficients. This may be explained if it is remembered that the magnitude of the end-plate drag is restricted by the result of the deflection on C_L. (See No. 3, Test Results, General.) Therefore, at very high wing lift coefficients the overall end-plate effect tends to reduce the induced drag, so that the plain wing polar is intersected near the stall. Below this, the CAEP produces, at the same angle of attack, more drag with no loss in lift. At a C_L of 1.0, the drag with 30° flap deflection is 20 per cent greater than the wing alone and 22.5 per cent greater than the neutral end-plate configuration.

The comparative stability curves are shown in Fig. 5. They show no adverse effects due to the CAEP. It is evident that the plates could be used to control pitching moment and longitudinal stability.

Curves of C_L^2 vs. C_D for six configurations are shown in Fig. 6. They show the magnitudes of the changes in profile drag and effective aspect ratio. It is seen that the two CAEP configurations not considered optimum actually show the greatest anticipated effects on induced drag. It is the attending changes in profile drag which render them less effective in producing the desired results.

Photographs of the tuft grid for the final four configurations at various angles of attack are found in Figs. 7 to 13. Figs. 7 to 9, taken at $\alpha = 16°$, show the reduction of the area of vorticity with the addition of the end plate and its deflection. Figs. 10 to 12, taken at $\alpha = 0°$, show the increase in vorticity due to the end-plate flap deflection. Fig. 13, taken at an 8° angle of attack, shows the simultaneous existence of two vortices because of the flap deflection. The elliptical shaped vortex of Fig. 9 is typical of the CAEP decrease drag configurations at higher angles of attack.

The results indicate that in the region of some design lift coefficient (about 1.4 for this case) the drag of the basic wing may be increased or decreased at the same angle of attack. At a C_L of 1.4 the drag decrease with respect to the basic wing is 12 per cent, with almost half of this value due to CAEP deflection. At the same C_L the drag increase is also 12 per cent above the wing alone. The maximum increase and decrease in drag over the plain wing value are above 20 per cent in each case, but they occur at widely different C_L's.

APPLICABILITY

It is believed that the control over drag afforded by the CAEP can be utilized to improve the take-off and landing performance of airplanes.

For the practical application the following will have to be considered:

(1) Weight of the end plates and mechanism.

(2) The effect of the end plates on the structural design of the wing and possible weight changes associated with it.

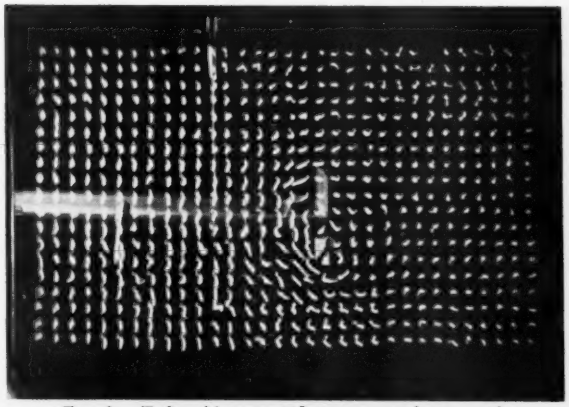


FIG. 9. Tuft grid, $\alpha = 16°$, $\delta_{EP} = -5°$, $\delta_F = 0°$.

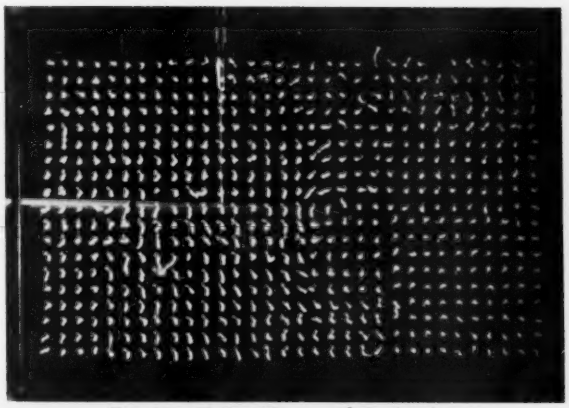


FIG. 10. Tuft grid, $\alpha = 0°$, basic wing.

(3) The mechanical problems of adjusting the plates in flight and reliability and complexity of the mechanism.

(4) Possible utilization of automatic control.

(5) The physical limitations to the size of end plate, such as ground or hangar clearance.

(6) The increase in profile drag in the high-speed condition and the possible use as a range-increasing device at long-range cruise.

(7) The effects of the end plates on longitudinal, directional, and lateral stability and control, for both the static and dynamic cases.

Some of these have been briefly taken up in an analytic study[1] where it was concluded that there is a practical application of the Canted Adjustable End Plate. Calculations, based on the theoretical effects of the end plates including weight and profile drag increases, show that take-off and landing performance can be improved in some cases.

The particular configurations for which the use of CAEP appears to be most useful are those utilizing boundary-layer control, swept wings, or both. For the boundary-layer control airplane, induced drag is a major portion of total drag; while for the swept-wing airplane, the plates could also serve as directional stability and control surfaces, so that profile drag and weight penalties would not be great. For the swept-wing airplane with boundary-layer control, the device appears doubly promising.

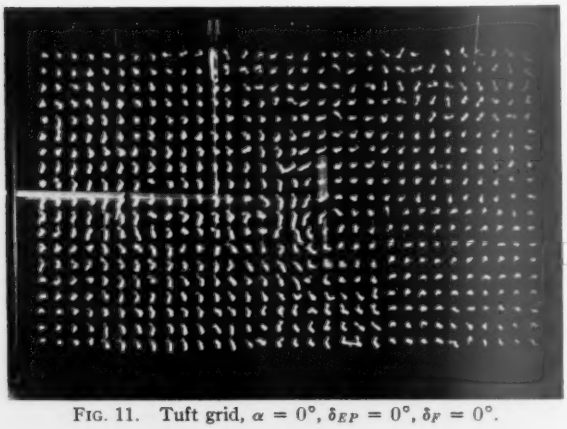


FIG. 11. Tuft grid, $\alpha = 0°$, $\delta_{EP} = 0°$, $\delta_F = 0°$.

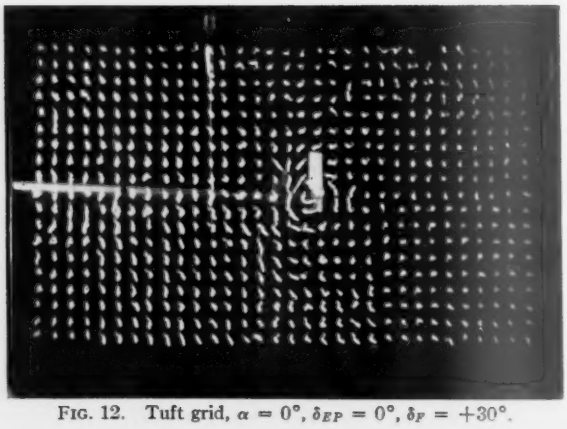


FIG. 12. Tuft grid, $\alpha = 0°$, $\delta_{EP} = 0°$, $\delta_F = +30°$.

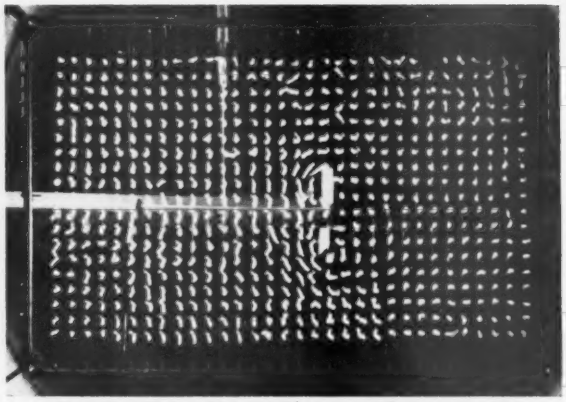


FIG. 13. Tuft grid, $\alpha = 8°$, $\delta_{EP} = 0°$, $\delta_F = -15°$.

The calculations of the analysis indicate that reductions of take-off and landing distances of from 15 to 25 per cent will be possible. It was further calculated that the end plates would cause a 2.5 per cent reduction in maximum speed for a liaison-type aircraft. For the swept-wing airplane, it would be possible that no performance item be sacrificed.

It should be noted that there is no evidence that the configuration tested is the optimum. The effects of such important factors as end-plate taper, thickness, differential area, or deflection above and below the wing—for instance—could have great influence. Variables in the basic wing, such as airfoil section and aspect ratio, should also be investigated. It would seem logical that the optimum overall configuration would vary with each individual aircraft, depending in particular upon the relative magnitudes of the induced and profile drags of the system.

Conclusions

On the basis of the results obtained in this investigation it is concluded that:

(1) Canted Adjustable End Plates can be used to control the drag of wings. The drag can be increased or decreased depending upon the end plate or end-plate flap deflection.

(2) The control over drag is obtained by displacing or adding to the wing-tip vortex and utilizing the profile drag of the device.

(3) This device can be used to improve the take-off and landing performance of airplanes.

(4) Further testing would be desirable to isolate the effects of the many variables associated with the idea.

References

[1] Clements, Harry R., *A Proposal for Canted Adjustable End Plates*, Cessna Engineering Report, October, 1953.

[2] Von Kármán, T., and Burgers, J. M., *General Aerodynamic Theory—Perfect Fluids Airfoils and Airfoil Systems of Finite Span*, Vol. II of *Aerodynamic Theory*, Div. E, Chapter IV, Sect. 19, Durand, W. F. (Ed.), Julius Springer, Berlin, 1935.

W. N. Stone* and N. R. Richmond†
The Kaman Aircraft Corporation

The Kaman Hydra-Mechanical Clutch

The design criteria, principles of operation, and specific weight data of a new helicopter clutch and freewheeling unit concept.

THE HELICOPTER INDUSTRY, relatively new in the aeronautical field, has had to concern itself with the problems associated with the behavior, control, and delivery of power to the main lifting rotor or rotors. Each of these design aspects is usually given more than a routine effort to conserve weight, simplify operation, and reduce overhaul and maintenance requirements.

For example, during the design and development of the HOK-1 helicopter, the clutch and freewheeling unit were given considerable attention, with the following design criteria being established:

Minimum weight.

Maximum simplicity for trouble-free operation and ease of maintenance.

Minimum space for clutch and freewheeling device.

Automatic maximum torque limitation to prevent transmission of high, instantaneous torque to the drive system.

Provision for manual clutch disengagement for below-deck warmup.

Smooth, rapid engagement, with no special pilot technique required.

Various designs were studied in successive attempts to achieve these criteria; the Kaman hydra-mechanical clutch finally evolved and is described in this paper.

A simplified drawing, Fig. 1, will be used to illustrate and explain the principle of operation of this combined clutch and freewheeling unit. Torque is transmitted through multiple wet discs, (1) and (2), which are forced together by 6,300 lbs. of hydraulic force at full r.p.m. and torque. By instantaneously and automatically reducing this hydraulic force to zero, thus allowing driven and driving discs to rotate with respect to one another, overrunning is achieved. The hydraulic pressure is supplied by a "scoop tube" type of pump, not requiring the usual number of moving parts. The scoop tube (3) does not rotate and is attached to the fixed aft hub (4) of the clutch. The open end of the tube is in the peripheral oil sump of the clutch which rotates at engine r.p.m. Hence, the kinetic energy of the high-velocity fluid, rotating with the outer housing (13), is converted to pressure energy at the end of the tube. This high-pressure oil—the pressure a function of the square of the r.p.m.—is directed through a transfer bearing (5), into the rotating clutch hub (6), and from there is led into the so-called "power annulus" (7). (See Appendix for pressure-r.p.m. equation.) The piston (8) thus compresses the clutch discs or plates, allowing torque to be transmitted to the output shaft (9). In addition, a torque-sensitive valve (10) and (11) is employed either (a) to close and allow the pressure to build up in the power piston annulus if the torque is supplied to the rotors or (b) to open to allow oil to dump from the power piston annulus, thus allowing the clutch discs to slip freely in the event that engine torque is less than rotor torque (autorotation).

Fig. 1 illustrates the torque path through the clutch, as well as the routing of the high-pressure oil. To complete the description of the unit, details of the torque-sensing valve and the multiple discs will be explained.

The design detail and operation of the torque-sensing valve requires consideration of the arrangement of the engine shaft, the clutch hub splined to it, and the hous-

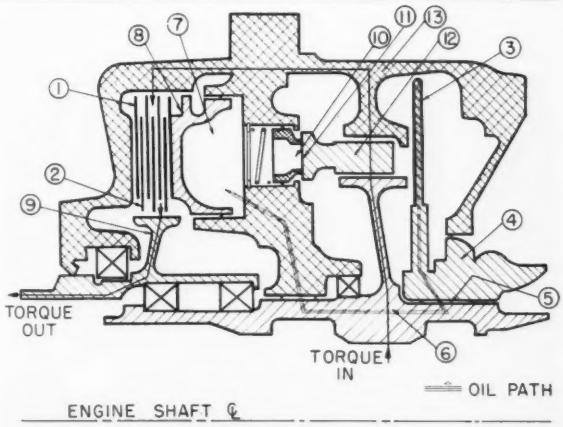


FIG. 1.

Presented at the Helicopter Design Session, 23rd Annual Meeting, IAS, N.Y., Jan. 24–27, 1955.

* Assistant Chief Engineer.

† Chief of Mechanical Design.

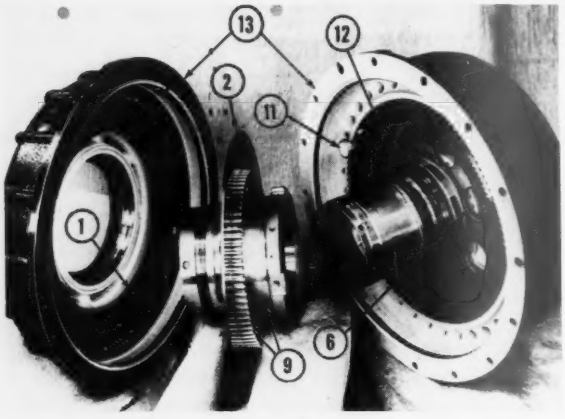


FIG. 2.

ing of the clutch to which are splined the driving discs or plates. It may be seen from an examination of Figs. 1 and 2 that the torque path from engine shaft to driving plates is via a double spline connection between the clutch hub (6), "torque ring" (12), and outer two-piece housing (13). Driving discs (1), splined to outer housing (13), transmit torque to driven discs (2), which in turn are splined to the clutch output shaft (9). The valve seat (11), proper movement of which is relied upon for automatic engagement and instantaneous disengagement in case of power failure, is attached to this torque ring. It is caused to move axially—closing or opening the valve, depending on the sense of torque—by virtue of a helical spline between clutch hub and torque ring and a straight spline between torque ring and clutch housing. These two splines are relatively loosely fitted and designed for low bearing stress to permit an easy sliding motion of the torque ring with reversal in steady torque direction.

Fig. 3 shows the details of the sensing valve itself: more than ample port area (1) is provided for maintaining the power annulus oil pressure at a minimum during negative torque or autorotative flight; a flat Teflon seat (2) is provided for the poppet that is free to rock a bit to seat squarely. Fig. 1 illustrates that differential area on the poppet itself permits the power piston pressure to maintain positively the valve in the closed and sealed position, during positive power delivery.

Fig. 4 is a photograph of the driving and driven clutch plates, the more interesting features of which will be described. The so-called driving plates are of steel, with sintered copper-iron facings; these plates are splined to the main housing, as mentioned heretofore. The driven discs, splined on their inside diameter to the clutch output shaft, are slightly coned or dished steel plates. The coning aids in separating the plates, allowing a thick wedge of oil to form during overrunning operation; this was found desirable to eliminate a tendency of completely flat plates to drag on one another, apparently due to a slight suction as a relatively thin film of oil centrifuged out of the interface. Springs are provided to retract positively the power piston (8 in Fig. 1) when the power piston pressure drops below a predetermined value. The number of discs and the hydraulic force applied at minimum rated r.p.m. have been proportioned to provide approximately 40 per cent margin over maximum attainable average engine torque. Easy, shockless engagement is thus provided, and, in addition, transmission of an excessively high torque impulse to the rotors—such as might be experienced with an engine backfire or malfunction—is prevented. The discs in this photograph have been used in excess of 250 hours at 600 hp., have been cycled through 500 engagements and disengagements, and have undergone simulated autorotation and idling tests totaling 80 hours. Each of these discs has worn less than 0.001 in. and is still entirely serviceable. It is estimated that a 600-hour operating interval can easily be attained.

The operation of the clutch may now be re-reviewed with respect to pilot technique:

Engine idling, rotor brake off—The mean position of the torque ring is retracted (torque-sensing valve open), thus never permitting any significant pressure—even the low pressure developed at 800 r.p.m.—to build up in the power annulus.

Pilot desires engagement—Pilot increases throttle smoothly and normally to any desired r.p.m.; rated r.p.m. may be achieved in about 5 to 7 sec. Torque ring moves forward, coming to rest against stops, closing

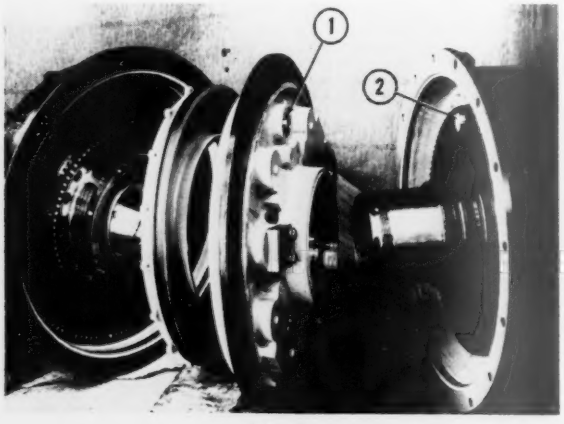


FIG. 3

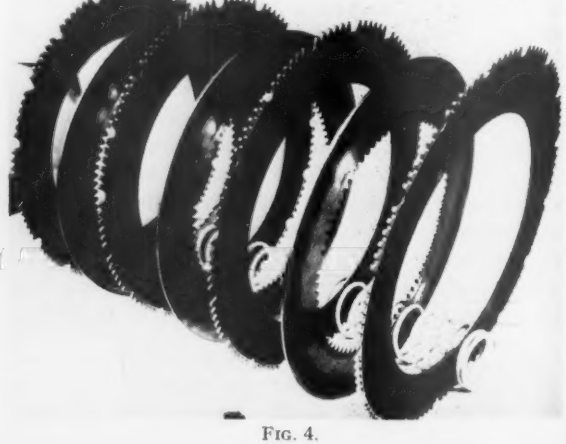


FIG. 4.

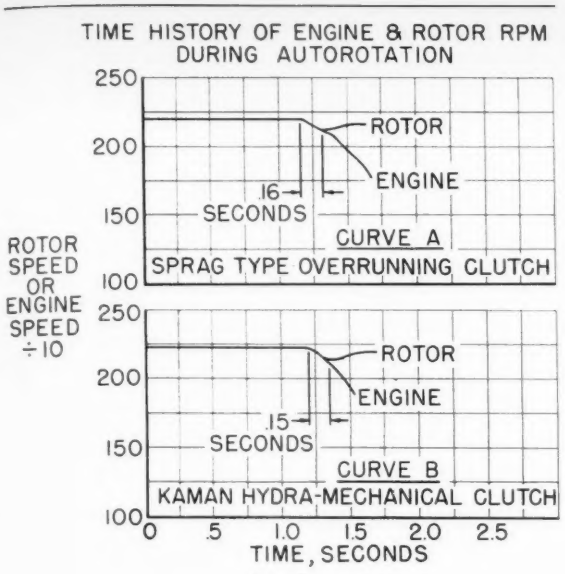
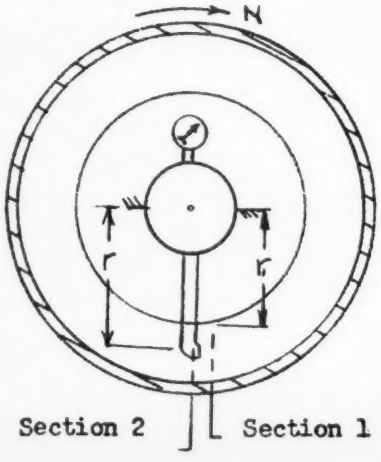


FIG. 5.

the torque-sensing valve. The oil pressure increases steadily with the hydraulic circuit now closed by the sensing valve. As the pressure increases, the power piston moves forward, the separating springs being overcome by the hydraulic force, the discs are forced together, and when the torque capacity of the discs—as represented by the net closing force and the coefficient of friction—becomes equal to the torque required by the rotor at a particular r.p.m. (about 1,100–1,200), the discs automatically marry, thus causing rotors and engine to be synchronized.

Autorotation or partial power descent—Upon power failure or throttle cut by the pilot, a reversal of torque occurs which as previously explained instantly moves the torque ring back, opening the sensing valve and dropping the power piston pressure to zero. The power piston moves back as well, and the driving and driven plates, relieved of all compression, immediately slip, permitting full overrunning. Fig. 5 gives some idea of the speed at which the aforementioned overrunning sequence takes place. This graph is a plot of actual rotor and engine r.p.m.'s during a ground simulation of power failure, with the original data taken from a movie of two sensitive tachometers. The time increment between power failure and what would be, in flight, the establishment of a steady autorotative r.p.m. is 0.15–0.20 sec. This is almost identical to that which is recorded for other types of overrunning clutches, as shown by comparing Curve A with Curve B.



Engine warmup, rotors stopped—A cockpit quadrant control of clutch engagement permits below-deck engine warmup. A shutoff valve is provided in the fixed aft clutch hub, which, it will be remembered, carries the scoop tube. This valve merely cuts off the supply of oil from the scoop tube, if it is desired to increase engine r.p.m. while not engaging the rotors.

Stopping the rotor, engine continuing to run—The pilot decreases the throttle to idle, disengages the clutch with the cockpit quadrant control, and applies the rotor brake.

From the foregoing, we may summarize operational features. Only two simple, automatic processes are required of the unit, with no pilot attention required in normal use: (1) Oil is supplied under automatically controlled pressure to the clutch pressure piston, with no moving parts normally inherent in pumps and associated relief valves. (2) The torque-sensing valve either moves forward and closes or moves aft and opens, depending upon torque direction. This inherent design simplicity is the cornerstone on which operational dependability, minimum maintenance, and maximum weight-saving are based.

The weight of the clutch is 76 lbs.; designed for transmitting 600 hp. at 2,250 r.p.m., the specific weight becomes 0.127 lb./hp. This compares with 0.17–0.19 lbs./hp. for a centrifugal-type friction clutch and freewheeling unit. The immediate growth potential of this specific clutch is appreciable—for instance, by the addition of one more driving and one more driven disc for which there is space, and for a corresponding weight increase of 3.36 lbs., the clutch capacity would become 800 hp. at the same r.p.m. This configuration would have a specific weight of 0.098 lb./hp. By taking advantage of the experience gained thus far, plus eliminating the weight penalty imposed by designing around standard engine propeller shaft, current design studies indicate possible weight-savings of 40 per cent, compared to the aforementioned data.

Summarizing our conclusions to date, we believe that the integration of the freewheeling feature into the friction clutch, combined with the functional and pilot technique simplifications, can properly be defined as a step forward in the helicopter power clutching art.

APPENDIX

(1) Body of fluid rotating at N (r.p.m.) (see cut)

(2) Stationary tube whose open end is located in moving fluid at radius r from center

(3) Theoretical maximum pressure P (lbs./in.^{2}) developed in closed pressure system in terms of:

rotational speed of fluid N (r.p.m.)
fluid density w (lbs./in.^{3})
radius at which open end of tube is located r (in.)
radius to free surface of fluid r (in.)

(*Continued on page 54*)

Fatigue Analysis of Aircraft Bolts

Tension fatigue tests of alloy-steel and aluminum Huckbolt installations, as well as standard aircraft (AN) bolt-nut combinations.

Harold G. Brilmyer*
Huck Manufacturing Company

Introduction

WHENEVER FASTENER FATIGUE STRENGTH is of paramount importance, the technical application of standard bolts and nuts has raised many questions such as, What torque? How tight is too tight? Cut threads or rolled threads? Dry threads or lubricated threads? Castellated or self-locking nuts? Does torque weaken bolts? Are lockwashers required?

These questions have prompted exhaustive analysis, to say the least, and the design and manufacture of bolts and nuts has become an exact science. However, there is one weak link in the chain of events necessary to ensure the proper installation of bolts and nuts—success or failure in fatigue is dependent on the man behind the wrench, and because of that fact alone it is obvious that too much is left to chance. The Huckbolt embodies an entirely new fastening principle that does away with this weak link and at the same time presents an installed fastener that develops a minimum endurance strength in fatigue equal to one-half its static tensile strength.

* Vice-President in Charge of Research.

Fatigue tests, the results of which are discussed in the following portions of this paper, were conducted at Battelle Memorial Institute. A method is presented for use in determining the tensile preload present in an installed fastener.

General Description

The Huckbolt consists of two precision-made parts, as shown in the diagram below.

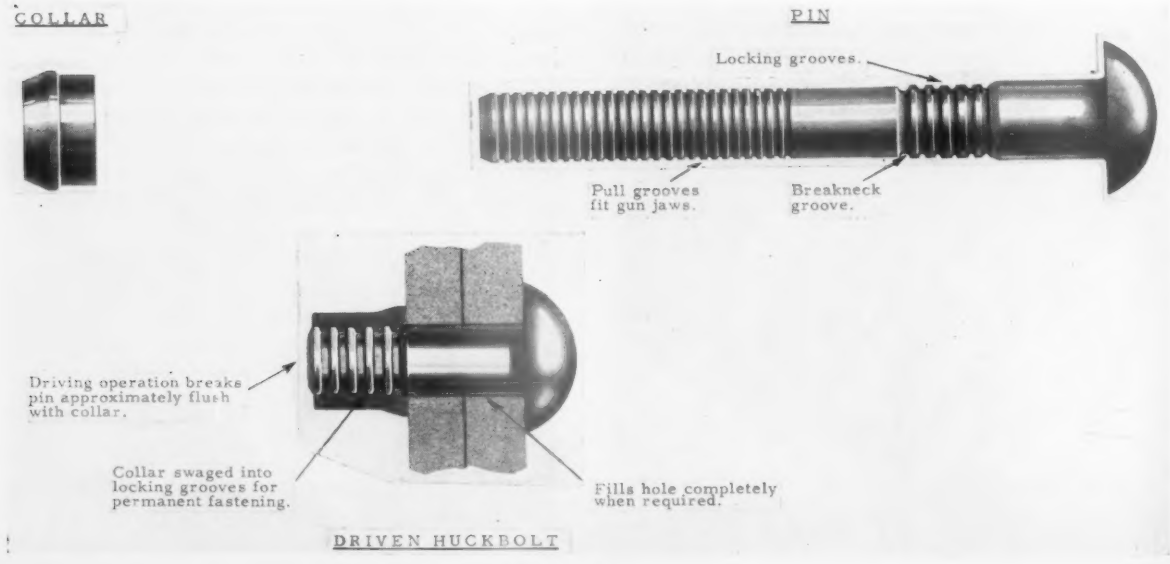
Standard Huckbolt Types for Aircraft Usage

Available diameters: $^3/_{16}$, $^1/_4$, $^5/_{16}$, and $^3/_8$ in.

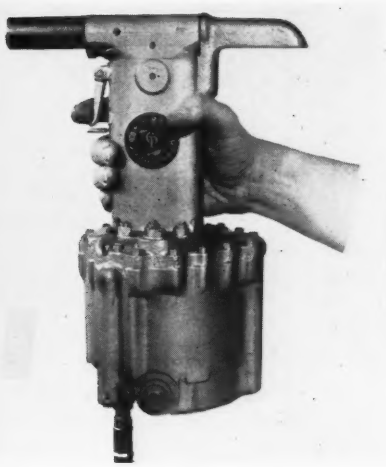
Available pin materials: Heat treated alloy-steel cadmium plated and 75S-T6 aluminum-alloy.

Available collar materials: 24S-T4 aluminum-alloy used with heat treated alloy-steel Huckbolt pins and 61S-T6 aluminum-alloy used with 75S-T6 aluminum-alloy Huckbolt pins.

Available head types: Pan head type, AN426 countersunk head type, and close tolerance AN509 countersunk head type.



Insert Pin
Install Collar
Attach Tool and Pull Trigger
Huckbolt Drawn Into Hole With Tight Press Fit
Sheets Drawn Tightly Together
Collar Swaged Into Huckbolt Grooves
Pintail Broken Off and Tool Disengaged
A Perfect High Shear and Tensile Strength Fastener Every Time



Strength Properties

Huckbolt Diameter, In.	Pin Material	Collar Material	Shear Allowable Design	Tension Allowable Design
3/16	alloy-steel	24S-T4	2620	2210
	75S-T6	61S-T6	1330	1375
1/4	alloy-steel	24S-T4	4650	4080
	75S-T6	61S-T6	2280	2535
5/16	alloy-steel	24S-T4	7300	4225
	75S-T6	61S-T6	3620	4025
3/8	alloy-steel	61S-T6	10500	5050
	75S-T6	61S-T6	5270	6275

Standard Huckbolt Types for Commercial Usage

Available diameters: $^3/_{16}$, $^1/_4$, $^5/_{16}$, and $^3/_8$ in.

Available pin materials: Mild steel (plated if required), 24S-T4 aluminum-alloy, and 61S-T6 aluminum-alloy. (Other materials are special.)

Available collar materials: Mild steel (plated if required) used with mild steel Huckbolt pins; 61S-T6 aluminum-alloy, used with either 24S-T4 aluminum-alloy or mild steel Huckbolt pins; and 61S aluminum-alloy, used with 61S-T6 aluminum-alloy Huckbolt pins. (Other materials are special.)

Available head types: Brazier head type, button head type, and 90° countersunk head type. (Other head types are special.)

Typical Shear and Tension Values for Commercial-Type Huckbolts

Huckbolt Diameter, In.	Pin Material	Collar Material	Typical Ultimate Shear, Psi.	Typical Ultimate Shear, Lbs.	Typical Ultimate Tension, Lbs.
3/16	24S-T4 alum.	61S-T6 alum.	41,000	1,280	1,175
3/16	mild steel	mild steel	60,000	1,735	1,815
3/16	61S-T6 alum.	61S alum.	30,000	937	588
1/4	24S-T4 alum.	61S-T6 alum.	41,000	2,245	2,100
1/4	mild steel	mild steel	60,000	3,023	3,080
1/4	61S-T6 alum.	61S alum.	30,000	1,640	1,050
5/16	24S-T4 alum.	61S-T6 alum.	41,000	3,480	3,275
5/16	mild steel	mild steel	60,000	4,970	5,084
5/16	61S-T6 alum.	61S alum.	30,000	2,545	1,638
3/8	24S-T4 alum.	61S-T6 alum.	41,000	5,095	4,730
3/8	mild steel	mild steel	60,000	7,040	7,200
3/8	61S-T6 alum.	61S alum.	30,000	3,730	2,365

Huckbolts are quickly and easily installed by use of pneumatic production driving tools. The driving operation is automatic and continuous, in the following sequence (see cut above):

In simple terms, the locking section of the pin consists of annular grooves that ensure that the collar when swaged cannot loosen because of vibration. The swaging anvil in the pneumatic gun custom fits the collar into these annular grooves producing a controlled tensile preload dependent not upon the operator but

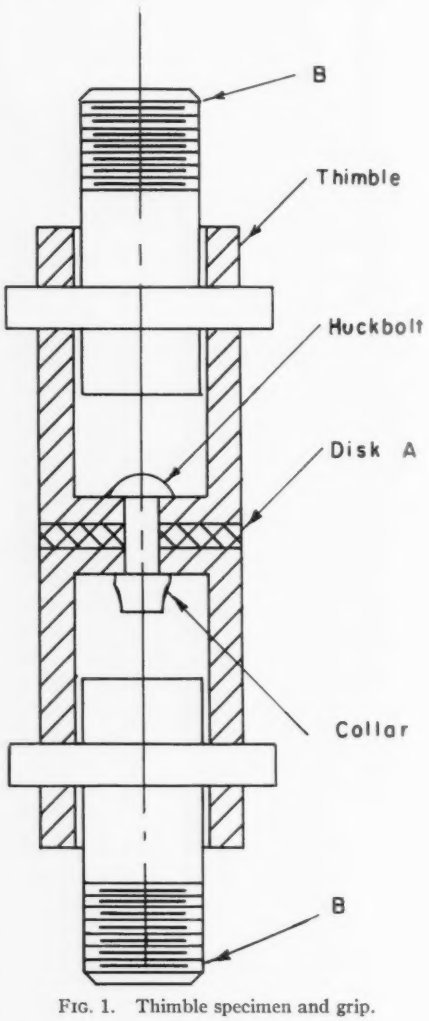


FIG. 1. Thimble specimen and grip.

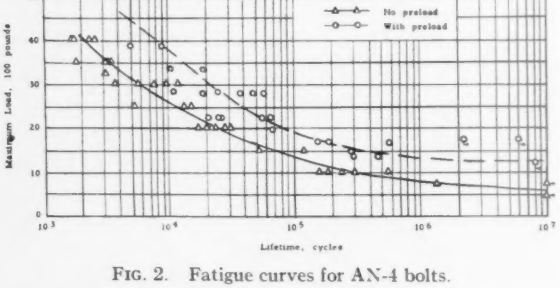


FIG. 2. Fatigue curves for AN-4 bolts.

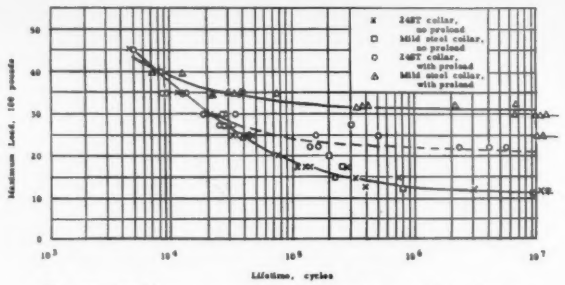

24ST collar, no preload
Mild steel collar, no preload
24ST collar, with preload
Mild steel collar, with preload
Maximum Load, 100 pounds
Lifetime, cycles

FIG. 3. Fatigue curves for $^1/_4$-in. alloy-steel Huckbolt.

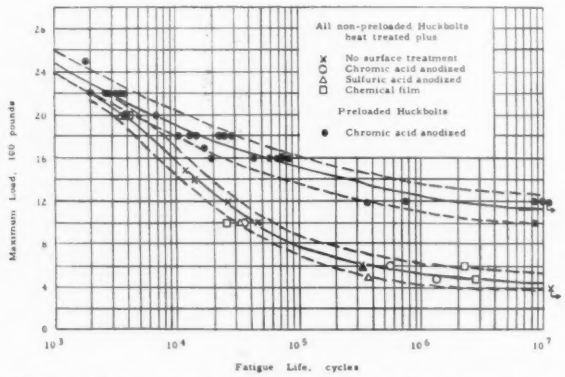


FIG. 4. Effect of surface treatment on fatigue behavior of 75S-T6 aluminum Huckbolts.

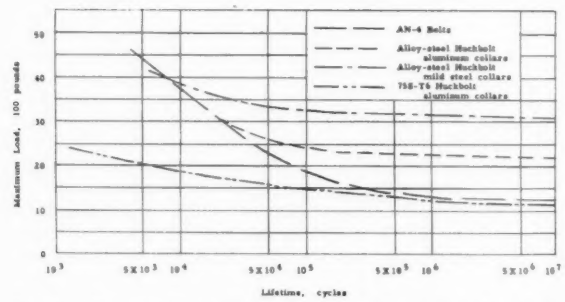


FIG. 5. Comparison of fatigue behavior of preloaded Huckbolts and torqued AN-4 bolts.

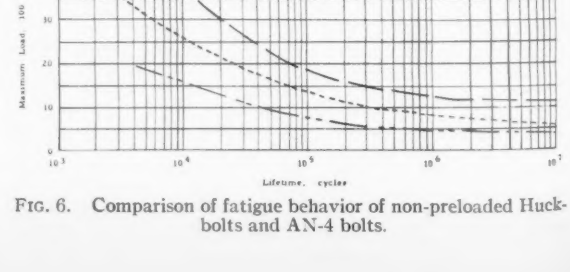


FIG. 6. Comparison of fatigue behavior of non-preloaded Huckbolts and AN-4 bolts.

upon the precision-made pin and collar. Since the pneumatic gun does all the work, the wrench formerly used by the assembly man is being rapidly replaced by this high production tool.

Tension-Tension Fatigue Strength

When considering the tension-tension fatigue strength of bolts, the literature emphasizes the fact that tensile preload—produced by torquing either the head of the bolt or the nut—results in improved fatigue behavior. (See references.)

Huckbolts have been so designed that a high tensile preload will be present in every installed fastener. Some discussion of the effect of tensile preload on the tension-tension fatigue behavior of Huckbolts has been made by W. S. Hyler and H. J. Grover.[2, 3, 4] The remainder of this paper will be devoted to a review of these fatigue reports.

Test Program

All specimens were tested in the special thimble-type fixture shown in Fig. 1. The tests were conducted at essentially $R = 0$ (the minimum load in each case was about 100 lbs. rather than 0 lbs.). *S-N* curves were developed for the fasteners for lifetimes ranging from about 1,000 to about 10,000,000 cycles.

A Krouse direct-repeated-stress testing machine was used for these tests. This machine operates at about 1,500 cycles per min. and is equipped with a cutoff device to stop the machine in the event of specimen failure or a load loss of the order of 20 lbs. Load was applied to the assembly at Point B (in Fig. 1) through universal joints, to prevent the occurrence of extraneous bending stresses.

Specimens Tested

AN bolts—cadmium-plated alloy-steel $^1/_4$-in. diameter bolts, heat treated to 125,000 to 145,000 lbs. per sq.in. (AN-4 type aircraft) were tested as follows:

(a) AN-4 bolts assembled without tensile preload were fastened with AN-310 nuts. These are cadmium-plated castellated nuts of mild steel. The nuts were finger-tightened and then backed off two turns. Cotter pins were used to eliminate the possibility of the nut loosening and consequent load loss during a test.

(b) The experimental work on AN-4 bolts assembled with tensile preload was performed a few years ago by Battelle[4] and is included in this paper for comparison purposes. In these previous tests, AN-365 self-locking stop nuts were used with a 0.050-in. thick flat-ground steel washer under the nut. Each bolt-nut assembly was preloaded to a wrench torque of about 70 in.lbs. prior to testing. This torque value was used because it was the upper limit of the range specified for general usage in the USAF *Handbook of Instructions for Aircraft Designers*.

These bolts have a minimum single shear strength of 3,860 lbs. and a minimum tensile strength of 4,080 lbs.

The *S-N* curve for these fasteners is shown in Fig. 2.

Huckbolts—the Huckbolts investigated were:

(a) $^1/_4$-in. diameter (type 4037) alloy-steel cadmium-plated pins (heat treated to 160,000 to 180,000 lbs. per sq.in.) assembled with 24S-T4 aluminum-alloy collars. The pins are designated ALPPH-T8-7, and the collars are designated LC-C8.

(b) $^1/_4$-in. diameter (type 4037) alloy-steel cadmium-plated pins (heat treated to 160,000 to 180,000 lbs. per sq.in.) assembled with C-1006 mild steel collars. The pins are designated ALPPH-T8-7, and the collars are designated LC-R8.

(c) $^1/_4$-in. diameter 75S-T6 aluminum-alloy pins assembled with 61S-T6 aluminum-alloy collars. The pins are designated ALPPH-E8-7, and the collars are designated LC-F8.

ANC-5 (June, 1951) specifies the following strength values for these Huckbolts.

Pin	Collar	Minimum Single Shear, Lbs.	Minimum Tensile, Lbs.
ALPPH-T8-7	LC-C8	4,650	4,080
ALPPH-T8-7	LC-R8	4,650	4,080
ALPPH-E8-7	LC-F8	2,280	2,535

The test procedure was as follows:

(a) For Phase I the Huckbolts were assembled as in actual service. Under these conditions a large tensile preload remained in the Huckbolt.

(b) For Phase II the Huckbolts were assembled as in actual service but the tensile preload was eliminated prior to fatigue testing by removing Disk A noted in Fig. 1. While bolts and nuts can and do loosen with a resultant loss of preload, the collar of the Huckbolt cannot loosen. If the fastener must be removed in service, it has to be cut off. (Note: This test with no preload was performed to show the basic fatigue strength of the Huckbolt design with the variable of preload removed.)

In the case of the 75S-T6 Huckbolts, the non-preloaded pins were also used to study the effect of surface treatment. Each of the following groups of pins was tested with no preload: pins having no surface treatment, chromic acid anodized pins, sulphuric acid anodized pins, and pins surface treated with a chemical film—Bonderite 710 (MIL-C-5541, March, 1950).

The *S-N* curves for these fasteners are shown in Figs. 3 and 4.

Analysis of *S-N* Data

Considering all of these fasteners on a comparative basis, Fig. 5 compares the normal Huckbolt installation with the data obtained on properly torqued AN bolts. (See Table 1.)

Of particular interest is the fact that the 75S-T6 aluminum-alloy Huckbolt has an endurance strength approximately equal to the alloy-steel AN bolt, while the alloy-steel Huckbolt with a mild steel collar has more than twice the endurance strength of the AN bolt.

Fig. 6 compares the basic (no tensile preload present) fatigue strength of these fasteners. Although this test

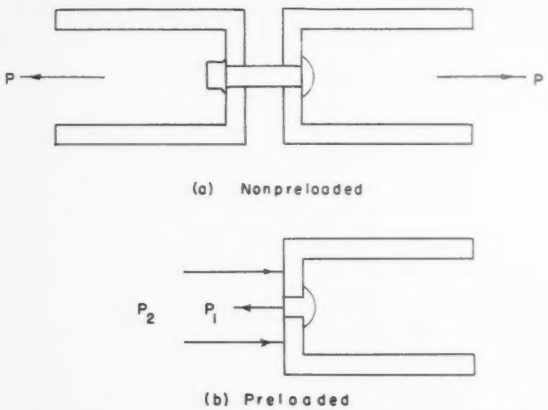


FIGURE 7. FORCE DIAGRAM FOR HUCKBOLTS

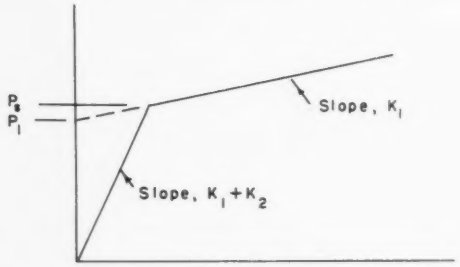


FIGURE 8. IDEALIZED LOAD-DEFORMATION CURVE FOR PRELOADED HUCKBOLT

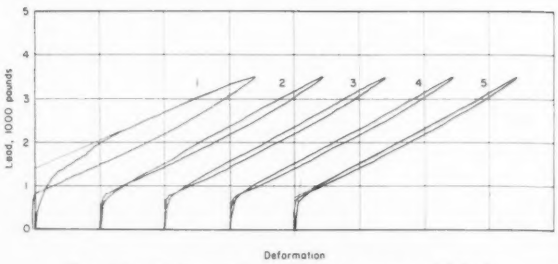


FIG. 10. Calibration curves for specimen 13-P-6.

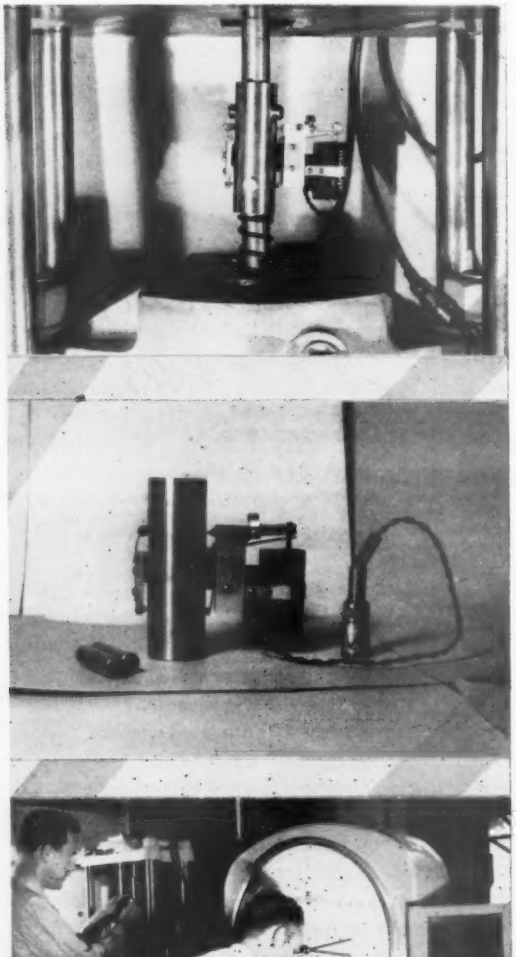


FIG. 9. Huckbolt calibration equipment.

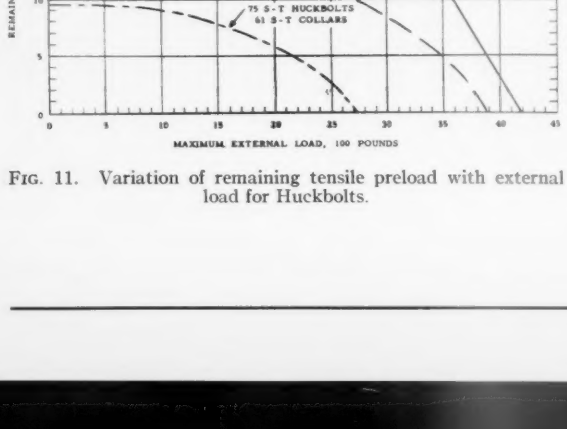


FIG. 11. Variation of remaining tensile preload with external load for Huckbolts.

TABLE 1

Tension-Tension Endurance Strength Comparison of 1/4-In. Diameter Alloy-Steel Standard Aircraft Bolts and Huckbolts

	AN Bolt	Alloy-Steel Huckbolt (Collars: 24S-T4)	Alloy-Steel Huckbolt (Collars: Mild Steel)	75ST Aluminum-Alloy Huckbolt
Rated tensile	4,080	4,080	4,080	2,535
Normal Installation				
Endurance strength (10,000,000 cycles)	1,275	2,040	3,000	1,100
No Tensile Preload				
Endurance strength (10,000,000 cycles)	625	1,175*	1,175*	500*

* Test conditions had to be artificially produced since it is impossible to install the Huckbolt without high tensile preload.

condition is impossible with the Huckbolt, it can happen to any bolt-nut installation. Particular attention should be given to the fact that the *S-N* curve for the non-preloaded alloy-steel Huckbolt and the *S-N* curve for the preloaded AN bolts are identical which simply means that, at best, a properly torqued AN bolt has the same *S-N* curve as an artifically produced "loose alloy-steel Huckbolt."

Analysis of the data for the 75S-T6 Huckbolts given various surface treatments indicated that the basic Huckbolt behavior was not affected measurably by surface treatments such as chromic acid anodize, sulphuric acid anodize, and chemical film treatment.

Determination of Tensile Preload

Fig. 7a shows a Huckbolt so assembled that the bolt has no tensile preload. It is apparent that any increase in the external load P on the thimble will be transferred entirely through the bolt. Provided deformation is elastic, the stretch of the bolt is directly proportional to the external load P. Thus,

$$e = P/K_1 \tag{1}$$

where K_1 is related to the length and area of the fastener and to the modulus of elasticity of the material.

When the Huckbolts have tensile preload, this simple picture is no longer true. Fig. 7b is a force diagram of a Huckbolt with tensile preload, however with no external load P. Obviously the pre-tension in the Huckbolt is balanced by compressive forces on the thimble face. Addition of an external load P would stretch the Huckbolt and relieve some compressive strain in the thimble face. If the load is not high enough to separate the joint faces, deformation of the bolt and the thimble must be equal. If the deformation is elastic, the strength of the bolt or thimble face is, again, directly proportional to the external load P. Thus, it can be shown that

$$e = P/(K_1 + K_2) \tag{2}$$

where K_1 is the stiffness of the bolt, and K_2 is the stiffness of the joint face.

Huckbolts were assembled in thimbles, and, prior to the fatigue tests, the assembly was calibrated. During calibration, the maximum load at which each specimen was to be fatigue tested was applied statically. Load-deflection data were obtained during these calibration tests. Fig. 9 shows the equipment used.

Fig. 10 shows typical calibration curves (load-deformation curves) for specimen 13-P-6. Since the specimen was fatigue tested at a maximum load of 3,500 lbs., it was calibrated to this value of load. Note that the maximum load was applied and released five times during calibration. The curve is essentially composed of two straight lines, as suggested by the idealized curve of Fig. 8. However, instead of a sharp transition (such as indicated in Fig. 8), there is a rounded transition region in Fig. 10. This probably results from some plastic deformation of either the collar material or the Huckbolt material in the locking grooves. It could be attributed also to other effects, such as bending of the thimble faces.

From the calibration data on all of the Huckbolts having tensile preload, it was estimated that the value of tensile preload following assembly was:

(a) 1,350 lbs. for 1/4-in. diameter alloy-steel Huckbolts with LC-C8, 24ST collars.

(b) 2,400 lbs. for 1/4-in. diameter alloy-steel Huckbolts with LC-R8, mild steel collars.

(c) 940 lbs. for 1/4-in. diameter 75S-T6 Huckbolts.

These calibrations further showed that application of maximum load in excess of the tensile preload caused some loss of tensile preload. Fig. 11 is a plot of remaining tensile preload versus maximum test load.

Conclusions

It is apparent from these fatigue tests that the alloy-steel Huckbolts performed considerably better than the AN bolts tested. For example, the Huckbolt tested in tension-tension fatigue without tensile preload behaved as well as the AN bolt tested with tensile preload. At 10^7 cycles, an alloy-steel Huckbolt assembled with preload can sustain almost twice the maximum load that a preloaded AN-4 bolt can sustain. If a steel collar is used (C-1006 material), the alloy-steel Huckbolt can sustain almost two and one-half times this maximum load.

The 75S-T6 aluminum-alloy Huckbolt at 10^7 cycles can sustain the same maximum load as a preloaded alloy-steel AN-4 bolt.

A number of factors might contribute to the lower fatigue strength of the AN-4 bolt. For example, the geometry of the AN-4 thread is more severe from the standpoint of stress concentration than is the geometry of the locking groove of the Huckbolt. There may be significant differences in manufacturing processes—viz., AN-4 bolts are heat treated to an ultimate strength of 125,000 to 145,000 lbs. per sq.in., whereas Huckbolts are heat treated to an ultimate strength of 160,000 to 180,000 lbs. per sq.in. This difference in strength level could account for some of the difference in fatigue behavior.

The study of the effect of surface treatments on the fatigue behavior of 75S-T6 Huckbolts was limited in extent. It was found that the basic Huckbolt behavior apparently was not measurably affected by surface treatments such as chromic acid anodizing, sulfuric acid anodizing, and chemical film treatment.

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The Newest Instruments for Astronomical Navigation

(*Continued from page 39*)

having continuous accurate knowledge of latitude and heading.

It would seem to be proper to employ the sextant, just described, in that role almost continuously, the latitude thus obtained to be fed into the star-data computer as input.

At the same time, a second automatic sextant of smaller aperture, smaller dimensions, and lesser weight could be directed to a planet or a first-magnitude star, obtaining an altitude to be fed into the star-data computer as second input datum together with declination and Greenwich hour angle of this second star, thereby determining longitude.

This approach, resulting in the continuous and almost completely automatic determination of geographic coordinates, would relieve the navigator, or the pilot-navigator, from the necessity of performing any sort of computation or of carrying precomputed data, a feature that is highly desirable in any type of fast aircraft. It is our goal to have the complete system available for service test in the latter part of 1955.

The Kaman Hydra-Mechanical Clutch

(*Continued from page 47*)

Using Bernoulli's theorem and considering the pressure and velocity heads at Sections (1) and (2)

$$h_1 + (V_1^2/2g) = h_2 + (V_2^2/2g)$$

Multiply by density w to convert to pressure

$$h_1w + (V_1^2w/2g) = h_2w + (V_2^2w/2g)$$

$$V_2 = 0 \quad \text{and} \quad h_2w = P_2$$

$$P_2 = h_1w + (V_1^2w/2g)$$

$$h_1 = (r - r_1)$$

$$P_2 = (r - r_1)w \times \frac{r}{386}\left(\frac{2\pi N}{60}\right)^2 + w \times \frac{(2\pi rN/60)^2}{2 \times 386}$$

$$P_2 = 0.0000284(r - r_1) \times rwN^2 + 0.00001419r^2N^2w$$

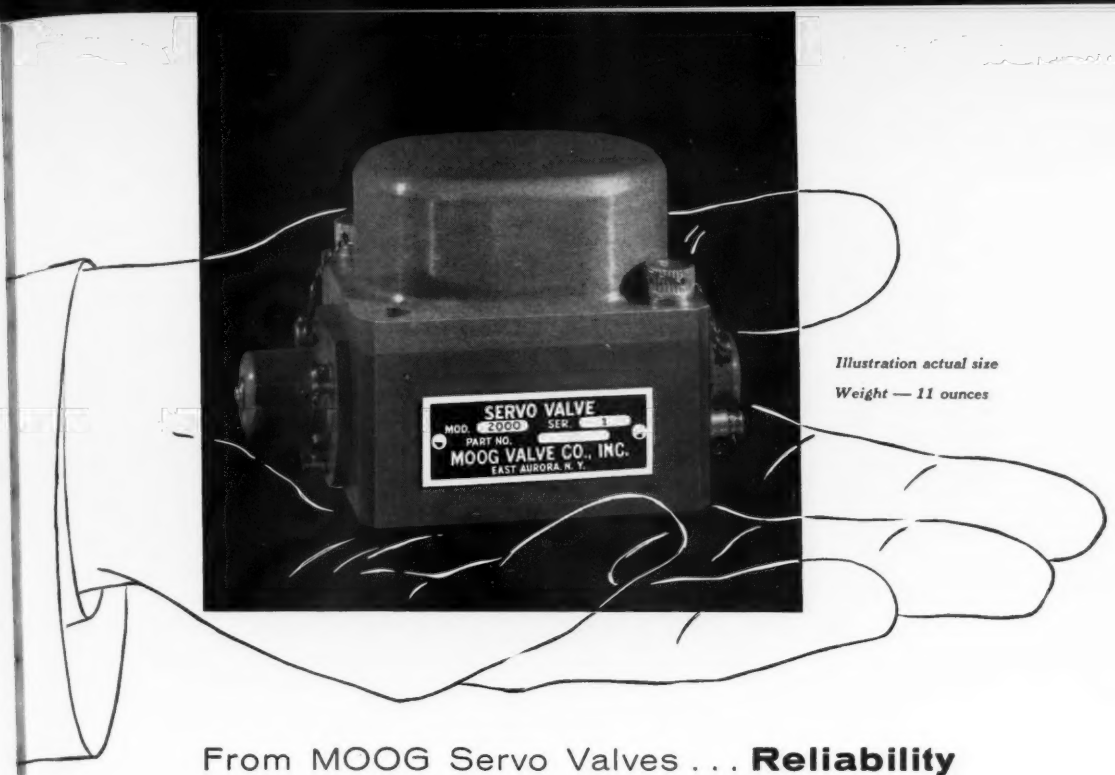


Illustration actual size

Weight — 11 ounces

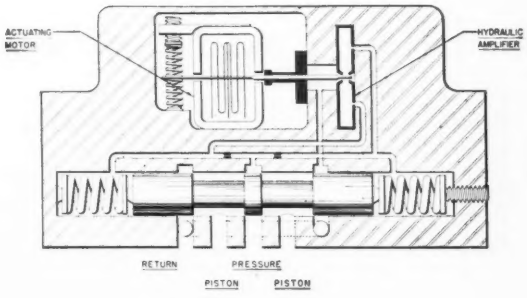
From MOOG Servo Valves . . . **Reliability and High Dynamic Performance**

Many thousands of Moog Servo Valves are now in use in exacting applications on advanced aircraft and guided missiles. This widespread usage attests to Moog features of reliability and high performance which have gained for these units recognition as the industry standard.

Now, these same features may be obtained in Moog's new Dry Solenoid Servo Valves. These units, illustrated above by Model 2000, feature a torque motor that is isolated from contact with the hydraulic fluid. The Dry Solenoids have been developed for those systems in which the fluid might otherwise contaminate the torque motor. They are even smaller and lighter than other Moog units of the same flow capacity and comply with requirements of MIL-H-5440A.

Moog Servo Valves are proportional type, electrically actuated, hydraulic, four-way valves featuring high dynamic response, sensitivity, linearity, small size and low weight. Production models are designed to operate in hydraulic systems of from 1000 to 3000 PSI pressure. Rated output flows from 0.1 to 50.0 GPM for control currents between 2.0 and 40.0 milliamperes as specified are available in production units.

Conventionally, valve input is from a balanced push-pull DC amplifier and valve flow output is applied to a piston or hydraulic motor. An electric signal proportional to piston position or motor angular rotation is fed back to the amplifier to give a closed servo loop.



MOOG

For details write for Bulletin 2000-1

MOOG VALVE CO., INC. PRONER AIRPORT EAST AURORA, N. Y.

Members on the Move

(*Continued from page 25*)

Technology. Formerly, Assistant Professor of Aeronautical Engineering.

Croydon H. Hartley (M), Foreign Activities Director, Servomechanisms, Inc. Formerly, Sales Director, Servomechanisms.

Douglas A. Heydon (TM), Engineer, Sparrow I Field Test Unit, Sperry Gyroscope Company, NAMTC, Point Mugu, Calif. Formerly, Engineer, Transport and Bomber Flight Control, Sperry Gyroscope Company, Great Neck, N.Y.

Clement V. Horrigan (TM), Mechanical Engineer, Metals Technology Branch, Mechanical Engineering Division, U.S. Army Quartermaster Research and Development Center, Natick, Mass. Formerly, Senior Analytical Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation.

Roy H. Isaacs (AM), General Manager, Eclipse-Pioneer Division, Bendix Aviation Corporation. Formerly, Director, Sales and Service, Eclipse-Pioneer Division.

William D. Perreault (AM), with Sales Branch, Lockheed Aircraft Corporation, Marietta, Ga. Formerly, Managing Editor, *American Aviation*, Washington.

Arthur E. Raabe (AM), Vice-President, Bendix Aviation Corporation, coordinating commercial aviation sales for twelve divisions. Formerly, Vice-President and General Manager, Eclipse-Pioneer Division.

S. Ramamritham (M), Deputy Director in charge of Research and Development, Civil Aviation Directorate, Government of India, New Delhi, India. Formerly, Senior Scientific Officer, Technical Centre, Civil Aviation Directorate.

Norman J. Tatham (M), Assistant Design Engineer—Combat Aircraft, Long Beach Division, Douglas Aircraft Company, Inc. Formerly, Design Supervisor, Mechanical Controls Section, Douglas.

Lewis W. Teel (M), Assistant Design Engineer—Transport Aircraft, Long Beach Division, Douglas Aircraft Company, Inc. Formerly, Project Engineer on C-133, Douglas.

Edwin L. Thomas (M), Director of Engineering, L. B. Smith Aircraft Corporation, Miami, Fla. Formerly, Assistant Chief Engineer, Temco Aircraft Corporation.

G. E. Woods-Humphery (AF), President, The Renfrew Aircraft & Engineering Co., Ltd., Renfrew, Ontario, Can. Formerly, Director, Flight Refueling, Inc.

Corporate Member News

• **Aerojet-General Corporation, Subsidiary of The General Tire & Rubber Company.** . .A new model of the Aerobee rocket, called the Aerobee-Hi, attained an altitude of about 123 miles with a 195-lb. pay load of instruments at Holloman Air Development Center. The Air Research and Development Command said the instruments in the nose cone, which landed safely by parachute, constituted the heaviest pay load recovered from a rocket flight thus far. The Aerobee-Hi, nearly 30 ft. long, has a rocket motor with 4,000 lbs. thrust. In a series of similar launchings, Air Force scientists hope to obtain data on solar radiation, sky brightness, and other phenomena at altitudes up to 135 miles.

• **Aeroquip Corporation.** . .A new plant has been purchased in Toronto for the company's recently formed subsidiary, Aeroquip (Canada) Ltd.

• **Aircraft Radio Corporation.** . .The new H-14A Omnirange Signal Generator, an improved version of the H-14, embodies eight major design changes. This unit is designed to test air-borne VHF omnirange/localizer receivers and to transmit signals to aircraft on the airport for ramp checking.

• **Allis-Chalmers Manufacturing Company.** . .Robert S. Stevenson, who joined the company as a salesman in 1933, has been elected President. He was formerly Executive Vice-President. William A. Yost, Jr., Vice-President—General Machinery Division, has been named Vice-President—Staff Operations. Harold M. Schudt has been elected President of Canadian Allis-Chalmers Limited.

• **Allison Division, General Motors Corporation.** . .Jet engines and related aircraft exhibits will share the spotlight with diesel locomotives, heavy earth-moving equipment, and the first gas-turbine automobile at the General Motors Powerama opening in Chicago August 31. An impressive array of heavy machinery will be assembled to demonstrate industrial power units in operation.

• **Aluminum Company of America.** . .A new high-temperature aluminum alloy, called X2219, is available in experimental quantities. It is claimed to have exceptionally good mechanical properties, tensile and yield strength, and resistance to creep at elevated temperatures in the range 500° to 600°F. Alcoa also is developing an alloy for sheet, plate, and extrusions in the 300° to 400°F. range. This alloy, which is now being tested, is expected to prove valuable for structural use in supersonic aircraft.

• **American Airlines, Inc.** . . .C-band radar will be installed this fall in American's 25 DC-7's used in transcontinental service and later in more DC-7's to be delivered in 1956. The company said the program will cost about $800,000. Air-borne radar will enable the pilots to avoid storm centers and turbulence. Operational experience with radar on long flights is expected to provide a good basis for evaluating its effectiveness.

• **Arma Division, American Bosch Arma Corporation.** . .A field office has been opened at 132 North Main, Dayton 2, Ohio, to facilitate liaison with the AMC and WADC at Wright-Patterson Air Force Base. Guy L. Antrim, Jr., is in charge.

• **Avien, Inc.** . . .A dual-display fuel gage with improved readability is in production for Navy aircraft. Total fuel on board is shown in a five-digit counter display. The amount of fuel in any individual tank is indicated by a pointer on a dial-edge scale.

• **Beech Aircraft Corporation.** . .By arrangement with the Morane-Saulnier Company of France, Beech plans to demonstrate the M-S 760 twin-jet, four-place executive transport throughout the United States and Canada this summer. Beech then plans to manufacture the plane, which cruises at 350 m.p.h. and has a top speed of 405 m.p.h.

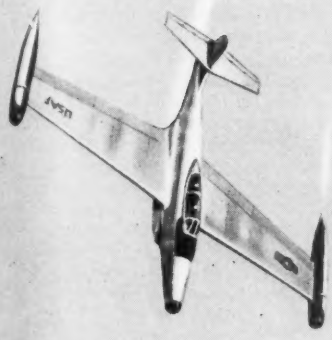
• **Bendix Aviation Corporation.** . .Automatic landing approaches and cross-country cruising on radio ranges have been accomplished successfully with air-borne equipment employing transistors in place of all vacuum tubes, Eclipse-Pioneer Division announced. The tests were made in the company's B-25 equipped with the new PB-20, which is basically a transistorized autopilot with an integrated electromechanical computer, requiring no additional equipment for automatic response to radio flight aids. Eclipse-Pioneer plans to use transistors in its integrated navigational flight system. . . .Nasco, Inc., at Miami International Airport, has been appointed by Eclipse-Pioneer Division as distributor for seven southeastern states.

• **Boeing Airplane Company.** . .The YC-97J, first of two Stratofreighters modified at the request of the Air Force to serve as flying test beds for the new Pratt & Whitney T34 turboprop engine, completed its first test flight successfully on April 19. The four turboprops, rated at 5,700 hp. each, give the plane 63 per cent more power and cut almost 5,000 lbs. off its weight. An extended test program will obtain data on turboprop tanker and transport operations. . . .Boeing has formed a new bomber weapons unit in recognition of the growing importance of electronics in weapons systems.

• **The Cessna Aircraft Company.** . .The CH-1 helicopter, which made its first test flight 1 year ago, has a forward speed of 122 m.p.h. at sea level or 110 m.p.h. at 5,000 ft., the company claims. Carrying two people, it is capable of hovering at 15,000 ft., and, with 400 lbs. added, it will hover at 11,000 ft. At 3,000 lbs. maximum gross weight and with fuel capacity of 60 gal., the helicopter can stay aloft 3.7 hours. Its single lifting rotor is powered by a Continental FSO-470-A engine delivering 260 hp.

• **Convair, A Division of General Dynamics Corporation.** . .A huge test stand for jet engines has been completed at the Fort Worth plant. Built of reinforced concrete and lined with sound-absorbing material, the building is 158 ft. long, 38 ft. wide, and 54 ft. high. . . .A large, general-purpose digital computer has been leased for the San Diego plant.

Vital Weapons

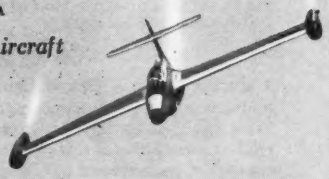


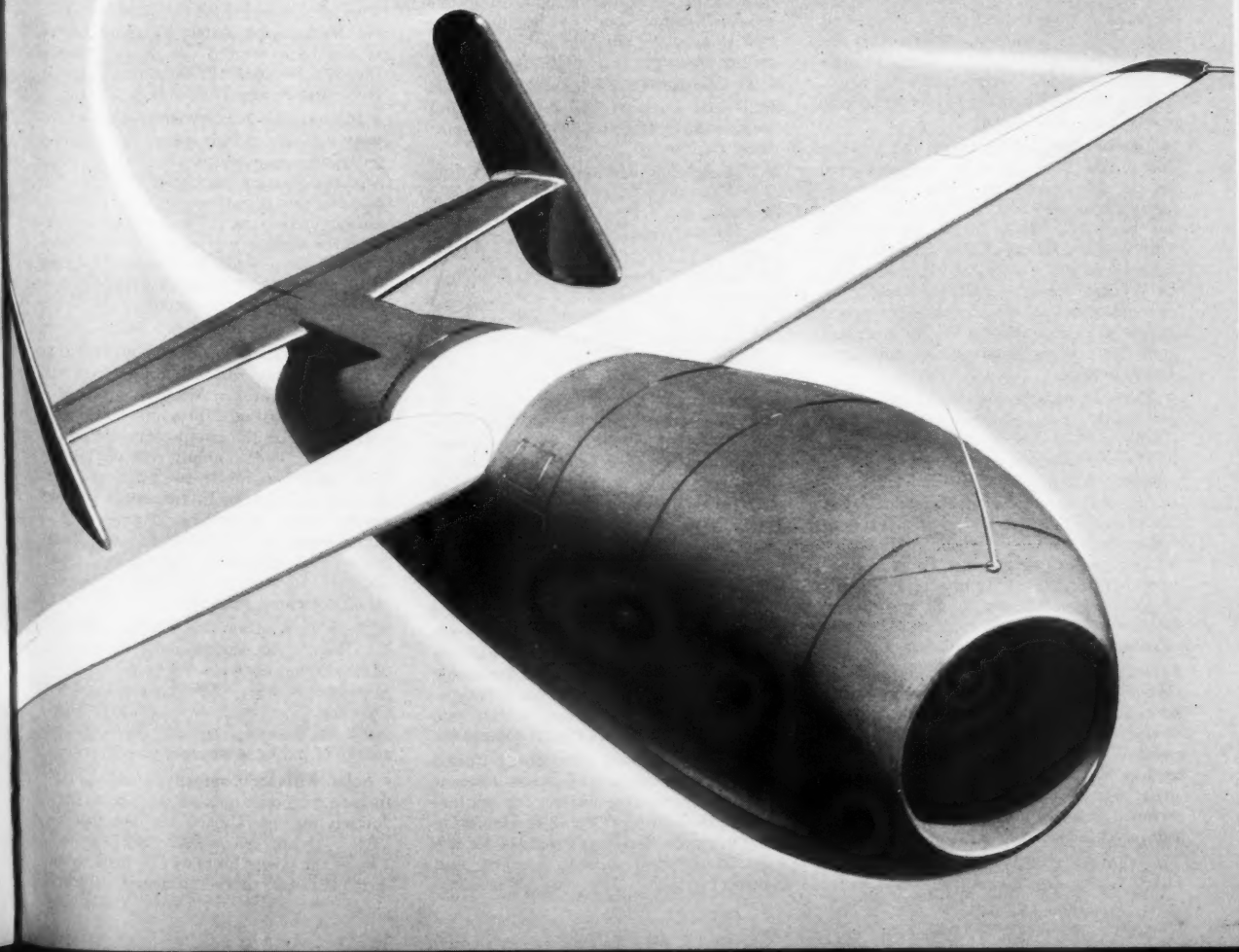
FORTY THOUSAND pilotless aircraft have been built since 1939 by Northrop Aircraft's subsidiary, the Radioplane Company. A pioneer in the field of unmanned flight, Radioplane is America's principal producer of radio controlled aerial targets. Propeller-driven drones and their new jet-powered counterparts are important members of the famed Northrop family of all-weather and pilotless aircraft. Together with Northrop's Scorpion F-89 rocket-armed interceptors, Snark B-62 long-range pilotless bombers, and many yet-to-be-disclosed developments, they are basic elements of this nation's power to deter enemy aggression.

NORTHROP

NORTHROP AIRCRAFT, INC. · HAWTHORNE, CALIFORNIA

Pioneer Builders of All Weather and Pilotless Aircraft





Lockheed RC-121D Super Constellations such as this, with radar domes protruding from top, bottom, and nose, are engaged in round-the-clock sentry duty off the East Coast with the 551st Airborne Early Warning and Control Wing of the Air Force. Equipped with wing-tip tanks, the RC-121D carries 5½ tons of electronic gear and a 30-man crew hundreds of miles out over the Atlantic at high altitude.

• **Decker Aviation Corporation. . .**A new multipurpose transducer component, utilizing the T-42 Ionization Transducer, is a ready-to-use unit for analog conversion of changes in capacitance to changes in voltage. The Decker Delta Unit may be used for measuring any physical phenomena that can be resolved into changes of capacitance, including micrometric and macrometric displacement, angular motion, vibration, temperature, pressure, liquid level, humidity, dielectrica, and continuous weighing.

• **Douglas Aircraft Company, Inc. . . .**The last C-124 Globemaster has been delivered to the Air Force. In 5 years, the company announced in a news release, Douglas built 445 of the huge, four-engined transports, each capable of carrying large vehicles or 200 troops. A gigantic turboprop cargo plane, the C-133, is slated to succeed the Globemaster as the largest transport in military service, the company said. It will be produced at the Long Beach plant.

• **Eaton Manufacturing Company. . .**Fredric Flader, Inc., an engineering and research firm, of North Tonawanda, N.Y., has been purchased by Eaton and will be operated as a subsidiary. Fredric Flader, FIAS, will continue as President. His company, which has 200 employees, specializes in the design and development of aircraft power plants and their components in the gas-turbine and jet-engine field. It also is active in the design and manufacture of special aircraft instruments, controls, and electronic devices.

• **Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation. . .**Arthur R. Lytle has been named Vice-President in charge of Research. Formerly Director of Research, he has been with the parent company since graduating from Rensselaer Polytechnic Institute in 1923.

• **Firestone Tire & Rubber Company. . .** Two synthetic rubber plants, located in Lake Charles, La., and Akron, Ohio, have been purchased from the United States Government for a little less than $16,000,000. Firestone has been operating both plants since they went into production under the Government's wartime program 12 years ago. Announcing it will spend $1,200,000 for expansion and improvements, Firestone said it is now in a position to produce 130,000 tons of synthetic rubber annually.

• **The Garrett Corporation. . .**AiResearch Industrial Division has been formed to manufacture turbochargers for heavy-duty diesel engines.

• **General Electric Company. . .**Engineers of the Aircraft Gas Turbine Division have devised a new way of recording jet-engine characteristics on about 175 calculator cards, thus greatly increasing the speed and accuracy with which the engine's performance in a proposed airplane can be calculated on an electronic computer. Use of the cards will save airplane manufacturers thousands of hours of calculating labor on every proposal, G-E said. . . .A high-voltage energy storage capacitor designed to operate in ambient temperatures above 150°C., yet made of nonstrategic materials, is being developed by G-E for use in jet-engine ignition systems. Not yet available commercially, the new capacitor is rated for use in the temperature range of 55°C. to 200°C. The unit is small and weighs about 1/2 lb.

• **G. M. Giannini & Co., Inc. . . .**The Giannini Datex Division has been formed to extend the automation activities of the Laboratory Apparatus Division. The new division will be concerned with automatic control and data recording for industrial processes and the conversion of data into digital form for use with digital computers.

• **Hamilton Standard Division of United Aircraft Corporation. . .**Fourteen different models of pneumatic starters for gas-turbine engines are now being produced by this Division. They are intended for use with 16 different fighter, bomber, and transport planes. Two types of combustion starters are under development for the Air Force. Turbine engine starters of the pneumatic type have been in production at Hamilton Standard for the past 4 years and more than 2,000 have been delivered, the company said.

• **Kollsman Instrument Corporation, Subsidiary of Standard Coil Products Co., Inc. . . .**In a list of recent engineering proposals covering devices for special applications, Kollsman mentions the following unclassified items: static pressure compensator, fore and aft acceleration switching system, cabin pressure control system, pressure ratio computer, jet-engine gross thrust systems, Mach Number and airspeed control system, master air data computer, self-powered pressure switch, multiple pressure switch assembly, dual pressure switch (absolute or differential pressure), altitude synchrotel transmitters, and instantaneous vertical-speed indicator.

• **McDonnell Aircraft Corporation. . .**McDonnell's XV-1 convertiplane has made the transition from vertical to horizontal flight—the first transition from helicopter flight to conventional airplane flight ever achieved. In announcing the successful test, the company said the four-place XV-1 was flown as a helicopter until its forward speed exceeded the stalling speed of its fixed wings; then power was shifted from the three-bladed rotor to a pusher propeller, and the rotor was allowed to windmill while the wings provided the lift. The rotor was driven by pressure jets at the blade tips. Three Associate Fellows of the IAS directed the development of the XV-1—Fred L. Doblhoff, Kurt H. Hohenemser, and Charles H. Hurkamp.

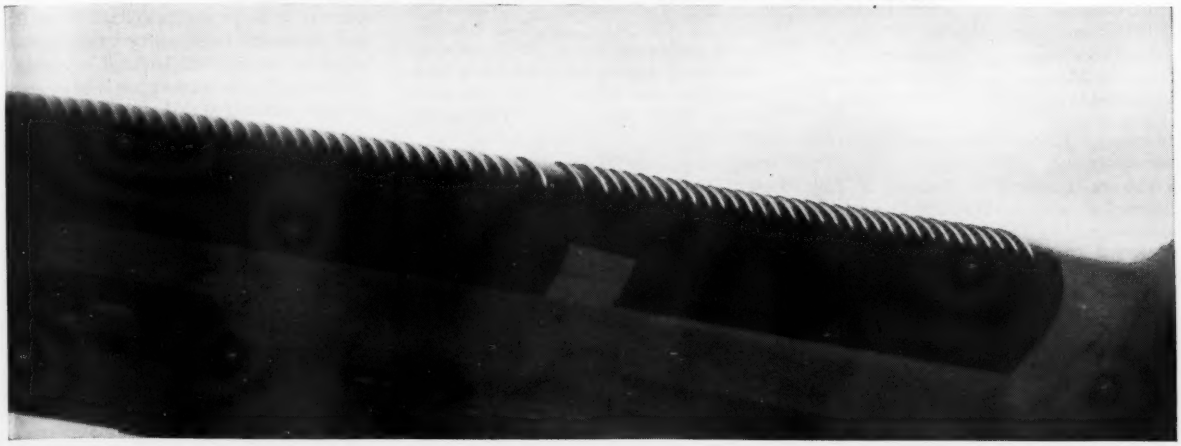
• **Minneapolis-Honeywell Regulator Company. . .**The punched-tape principle of automatic operation has been applied to a precision boring machine used in the manufacture of instrument gear trains for aircraft indicators. The Aeronautical Division is conducting studies to determine if the machine would be suitable for similar work in the production of highly precise gyroscope parts, servomotors, and other aeronautical equipment.

• **Pan American World Airways, Inc. . . .** Pan American will cooperate with the Foreign Operations Administration in a technical assistance program to expand and modernize the air-transport system of Pakistan. The company will send a 24-man team there for 3 years to instruct employees of Pakistan International Airlines in all phases of air-line operation. Air-line development is regarded as the cheapest method of stimulating commerce and industry in this country where surface transportation is difficult.

• **Republic Aviation Corporation. . .**Walter G. Bain, Vice-President and General Manager, has been elected to the Board of Directors. Ken Ellington has been elected a Vice-President; he also will continue as Assistant to the President, in charge of public relations and advertising.

• **Solar Aircraft Company. . .**Mars gas-turbine air-borne generators are in production for use aboard the Convair C-131B "flying electronic laboratories." Two of the power units will be installed in each plane to supply the heavy electrical

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER



New De-Icers mark B. F. Goodrich's 25 years of leading fight on ice

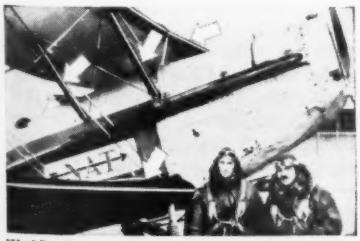
New chordwise De-Icers improve airflow

You're looking at the most efficient ice protection yet developed—new B. F. Goodrich chordwise De-Icers.

The small rubber tubes that inflate to snap off ice are built chordwise, in line with the air stream. This enables the De-Icers to maintain a smooth flow of air over the wings even during the brief three-second inflation cycle.

New BFG chordwise De-Icers are standard equipment on TWA's Super-G, above, also Lockheed's 1049-G's for Northwest. They climax 25 years of leadership in the fight against ice. We first gave airplanes ice protection in 1930. Here's how we started...

1927—Most planes still grounded in cold weather. Ice often forces airmail pilots to turn back or bail out.

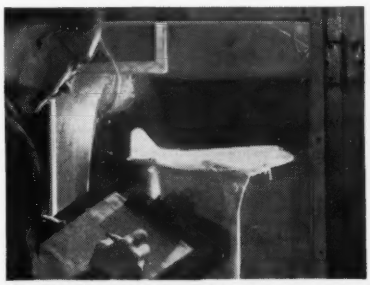


World's first ice protection system, BFG De-Icers tested on Douglas mail plane.

1928—Dr. William C. Geer and B. F. Goodrich engineers develop world's first ice protection—a rubber "overshoe" containing inflatable tubes that crack off ice. Copyrighted name: De-Icers.

1929—First flight made by planes with test sections of De-Icers.

1930—First flight of a plane completely equipped with De-Icers. Although hand pumped, BFG De-Icers bring plane through severe icing conditions.



B. F. Goodrich builds world's first refrigerated wind tunnel to speed work on ice problems.

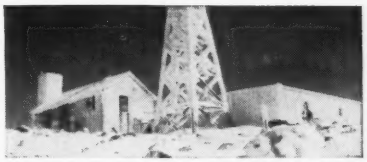
1931—BFG's "Miss Silvertown" is first plane to have engine-driven pump for inflating De-Icers.

1932—First commercial installation of De-Icers on fleet of Northrop Alpha mail planes. Soon followed by installation on Boeing 247's, Douglas DC-1's and DC-2's, Martin B-10's and pursuit ships piloted by Jimmy Doolittle.

1936—By now De-Icers have been made more efficient by increasing number of tubes and making them smaller.

1938—B. F. Goodrich develops De-Icers for 4-engine flying boats and transports.

1940—Improved air operating system results in faster tube inflation-deflation.



B. F. Goodrich pioneered use of Mt. Washington, N. H., for aircraft ice removal tests.

1942—Every U. S. combat bomber and personnel-carrying transport is equipped with B. F. Goodrich De-Icers. Throughout war, dependable De-Icer operation saves thousands of lives, many planes.

1943—Solenoid manifold distributor system with electronic timer gives infinite variations of De-Icer control. This new De-Icer control system used on B-29's flying on first Tokyo raids.

1948—100,000th BFG De-Icer installed. All major airlines that fly in icing conditions use De-Icers.

1952—New super-small tube De-Icers installed on all Super Constellations. Cemented on, new De-Icers eliminate fairing strips, assure longer life.

1955—First B. F. Goodrich chordwise De-Icers installed on Lockheed 1049-G's.

Only B. F. Goodrich makes De-Icers. Only B. F. Goodrich can give you the proved advantages of De-Icer protection. For special applications, B. F. Goodrich has also paralleled De-Icer progress with developments in chemical and electrical ice protection. *The B. F. Goodrich Company, Aeronautical Sales, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER

demands of radar and other devices. They will be hung from the wings in spun glass pods. Solar also is building gas-turbine-powered generators for the Douglas C-124C Globemaster and for the Lockheed C-121C Super Constellation.

• **Summers Gyroscope Company. . .**The Board of Directors has elected three new Vice-Presidents—John W. Brubaker, in charge of engineering; Marvin B. Ruffin, customer relations; and Jerome Domb, manufacturing.

• **Vickers Incorporated, Division of The Sperry Corporation. . .**Vickers' El Segundo Division, at Los Angeles Airport, has been expanded to provide complete facilities for the design and manufacture of special hydraulic valves for air-borne application. . . .The company announces a new line of oil hydraulic motors having integral speed control for constant speed applications in aircraft hydraulic systems. The Series MRO motors, manufactured in Detroit, are available from 2.3 to 18 hp.

• **Western Gear Works. . .**Bernard J. Bannan, formerly General Manager of the company's six plants, has been elected Vice-President in charge of Operations. L. A. Myhre was named Vice-President in charge of Marketing, and Paul Mehren, Secretary-Controller. . . .Western Gear announces a new air-borne accessory drive gear box, with a self-contained lubrication system, which may be used as a continuous-duty unit.

• **Westinghouse Electric Corporation. . .**A small lamp that can withstand centrifugal forces up to 1,000*g* has been developed for use as an identification lamp for helicopters, to be attached to the blade tips. The new light may make it possible to fly in formation at night. . . .Westinghouse scientists have developed a method of purifying titanium called "cage zone refining." The bar of metal is melted from the inside, in an atmosphere of inert gas, so that the metal acts as its own crucible, preventing contamination.

IAS Sections

Atlanta Section

Edith H. Lively, *Secretary*

The Atlanta Section met on March 10 at the Ship-A-Hoy Restaurant, with Chairman E. I. Bricker presiding. Brigadier General A. W. Beeman, Commander of Atlanta General Depot, and other distinguished visitors were recognized in the audience.

Mr. Bricker announced that the April dinner meeting, to be held at the Atlanta Athletic Club, would be called President's Night in honor of the speaker, Robert E. Gross, President of the IAS and of Lockheed Aircraft Corporation, Mr. Bricker then turned the meeting over to Otis Norcross, Program Chairman.

It was Mr. Norcross' pleasure to introduce as the guest speaker a friend of his from high school days, Brig. Gen. William C. Westmoreland. General Westmoreland, a graduate of West Point, Class of 1936, served as Chief of Staff of the 9th Division in World War II, seeing service in both Africa and Europe. Later he commanded the 504th Infantry (Parachute Regiment), was Chief of Staff of the 82nd Airborne Division, and was Commander of the 187th Airborne Regimental Combat Team in Korea. General Westmoreland's subject was "Army Mobility," with stress on the use of aircraft now and in the future.

The three major components of our defense forces today, he said, are completely complementary: each plays a part that the others cannot play, and each has unique capabilities. He stressed the capabilities of the Army and outlined the basic principles of warfare. Most of these principles can be achieved only with superior mobility. This is particularly true in regard to dispersion, a new principle of war necessitated by the atomic bomb.

"Mobility is a state of mind," said the General, "and is not necessarily completely dependent upon the speed of the means of transportation of the moment. The prime consideration is the retention of the edge of mobility over the enemy; thus we must have diversified mobility. The country which retains the edge of mobility can effectively apply the principles of war. The country which does not retain it will encounter grave difficulties."

General Westmoreland used slides to illustrate examples of mobility in World War II and Korea and discussed how present-day aircraft have increased our mobility potential. He stated: "The progress which has been made in aircraft development since World War II has been tremendous. The progress which has been made in the development of lighter ground equipment has been disappointing." Slides of newer equipment, from planes to tanks, were shown. In discussing some of the problems of atomic war, he stated that "if we are prepared to be highly mobile under conventional systems, we will gain a bonus under atomic conditions."

The speaker went on to point out: "The combat zone of the past was 'linear.' The front was a narrow, concentrated belt of front lines, reserves, and supply dumps. The concentration of forces thus involved would make ideal atom targets. The future combat zone will be 'cellular.' Forces must be dispersed and in great depth; the combat zone will increase in depth to perhaps 50 to 100 miles. This combat zone will be interspersed with held areas. Forces must have great mobility so that units and installations can be moved easily and be sufficiently dispersed to make poor atom targets. Between held areas, and between them and the dispersed bases of supply, will be large vacuums. There is only one way we can hold ground in this pattern, and that is to be much more mobile than the enemy. We must have operational mobility within the combat zone by both ground and air and greatly increased logistic mobility from supply bases to forward combat units. Long lines of ground communications for logistic purposes must in large measure be succeeded by air communications. We must gain the capability of operating in the third dimension all the way to the forward battle areas."

In his closing statements General Westmoreland said: "*Relative* mobility by our Army has always existed. . . . If we are to maintain this lead in mobility, we must all gear our thinking to the requirement with the same determination that has made the gaining of it possible in the past. Within the Army, it is our job to key our thinking to the mobile requirements of the future and to translate that thinking into positive action. You outside the Army have an equally great part to play. You must assist in providing the equipment that will make it all possible: first by designing and producing aircraft with the required usability and flexibility; and second by helping us to design and produce effectively combat equipment that can be transported economically by air.

"You in the aircraft industry have played a vital and highly effective role in achieving the mobility that the Army Forces possess today. Nevertheless, much remains to be accomplished. Your scientific, engineering, and productive genius is essential to our efforts to win the battle for greater Army mobility. Increased mobility of Army Forces is essential to deter or win future war."

Baltimore Section

Raymond D. Blakeslee
Secretary

The Baltimore Section held a confidential meeting April 14 at the plant of Flight Refueling, Inc., with 144 persons attending. A dinner and a tour of the plant preceded the meeting.

Chairman Herman Pusin dispensed with the Secretary's and the Treasurer's reports in order to hear a welcoming address by C. W. Newhall, President of Flight Refueling, Inc.

Mr. Pusin then introduced William Street, Chairman of the Program Committee, who presented the speakers of the evening—Theodore R. Farrington

of Wright Air Development Center, who spoke on "Technical Developments of Inflight Refueling Systems," and Capt. Noel Gaylor, USN, who spoke on "Carrier-Based Refueling Operations." Mr. Farrington outlined the past problems, the current methods of development, and the future Air Force plans for inflight refueling. Captain Gaylor discussed the history, developments, problems, and plans of the Navy's activities in inflight refueling.

Chicago Section

Leland W. Sims, *Secretary*

The Chicago Section held a dinner meeting on April 20 at the Museum of Science and Industry. Chairman Richard A. Schram welcomed 40 members and guests and then called upon William Sauers of the Membership Committee to introduce the speaker of the evening.

Explaining that Major Gen. Fred Dent, Jr., the scheduled speaker, had been unable to attend, Mr. Sauers introduced Col. Walter R. Graalman, Director, Procurement and Production, Mobile Air Materiel Area, USAF, who represented General Dent.

Colonel Graalman described the organization of the Air Materiel Areas, the object of which is to decentralize the maintenance, procurement, and production responsibilities of the Air Force into several geographic areas. He concluded with a question-and-answer period.

New officers will be elected at the annual business meeting in May, which will be the last meeting until fall.

Dayton Section

Gunther R. Graetzer, *Secretary*

At the monthly meeting of April 28, appropriately held in the Aviation Room of the Miami Hotel, Chairman George McTigue announced the slates of the 1955–1956 Section officers. After the dinner, the Chairman introduced the speaker of the evening, Col. Bernt Balchen, who presented "Arctic Flight Operations." Not often is a speaker able to present scientific material in such a way that it has life and color. This speech combined an unparalleled knowledge of the subject with such an exciting, dramatic impact that many fiction stories seemed pale compared with Colonel Balchen's talk about this pioneer experience in the Arctic.

Born in Norway, Colonel Balchen received his technical training in both Norway and Sweden. He accompanied Amundsen, Ellsworth, and the Nobile Arctic expedition and was chief pilot on the Byrd Antarctic expedition in 1928. Byrd and Balchen are the only men who have been over both the North and South poles. Colonel Balchen is now

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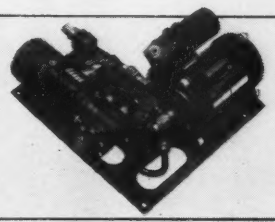

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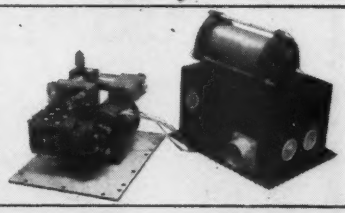
- Life is 500 operating hours
- Weight is 8 lbs. maximum



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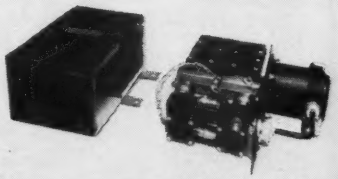

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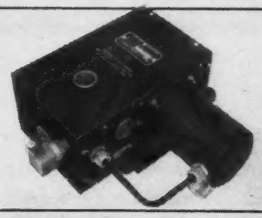
- Weight is 10-3/4 lbs. maximum



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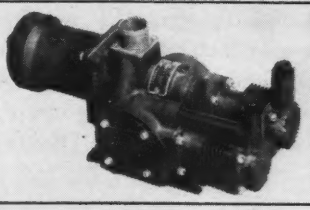
- Life is 1,000 operating hours
- Weight is 8-1/2 lb. maximum



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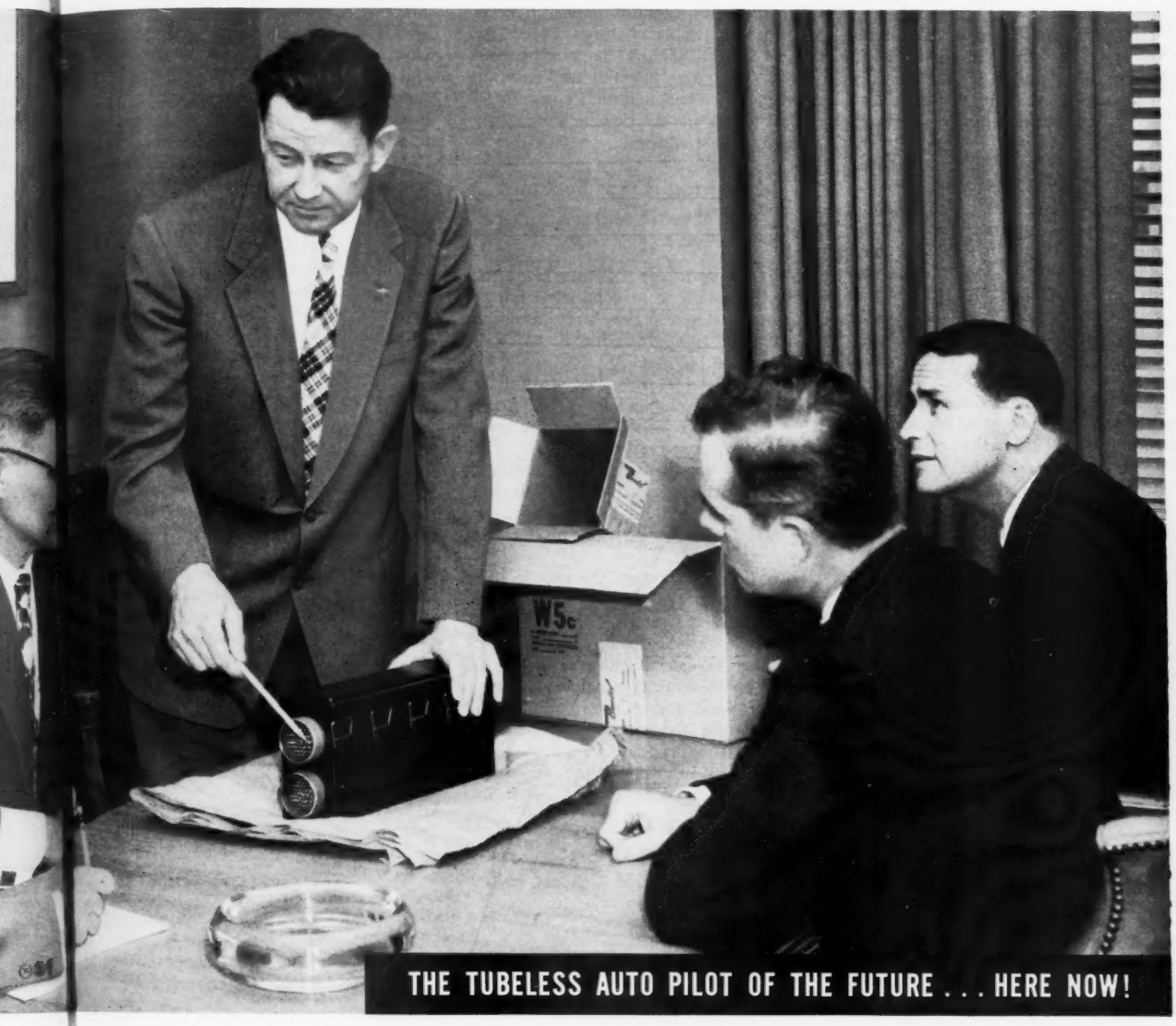

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Bendix AVIATION CORPORATION

Special Assistant for Arctic Activities in the Operational Plans Division of the Directorate of Operations, USAF Headquarters, Washington, D.C. The Dayton Section was fortunate indeed that Colonel Balchen, on his way to Alaska, could stop in Dayton to present his speech, which attracted a record attendance of 110 members and guests.

Balloons to the Arctic, the speaker said, were proposed as early as 1872, but a dirigible was used in 1926 by Nobile and was in competition with boats, dogsleds, and airplanes. A milestone in favor of the airplane was set by the Russian nonstop flight over the Arctic from Moscow to the United States, in 1937.

World War II started a new concept of air power, a new thinking of world geography: the shortest route for many long-range flights is the great circle course over the Arctic. From Dayton to England, from New York to Japan, the shortest route is over the North Pole. Thousands of aircraft hours were flown over the Arctic for logistic support, and a fundamental store of knowledge of the great problems was obtained. Of course, no magnetic compass can be used, but celestial navigation is reliable even for supersonic aircraft.

The real difficulties, in addition to weather reports and communications, lie in establishing operational bases, ground handling of aircraft, and choice of personnel. At −40°F., people from other climates cannot accomplish hard work—they just survive. Colonel Balchen suggested that a full year of life in the Arctic is necessary before the right selection for a long-duty Arctic Division can be made; this Division in turn would serve to train new people. The Arctic adaptability of people seems not much influenced by the climate in which they lived previously but rather by psychological acceptance. Only after 1 year can the selected people be trained in handling tools, drying clothes, preparing housing, ventilation, humidity control, nutrition, etc. After this training, they can start to tackle the real problems of building aircraft bases. The difficulties are (1) the short navigation season for supply boats, without docks or harbors, under changing ice conditions; (2) permafrost—i.e., permanently frozen ground with no way of getting water by drilling; (3) the impossibility of draining swampy regions where water is flowing underneath; and (4) the sewage disposal, which must be done by trucks, since a sewage water line would need heating.

The main difficulties with aircraft are the starting, servicing, and runways—the latter are asphalt hardtop, not concrete. For long-time stations, a heated hangar for fueling, warmup, and preflight is necessary. Luckily, jet engines are easier to maintain than reciprocating engines. Manifold are the headaches over problems still unsolved, but the overall picture is encouraging. With long-range planning and constant progress, we can maintain communications across the Arctic which are essential for peace and war.

Hampton Roads Section

William D. McCauley
Recording Secretary

Eighty members of the Hampton Roads Section were conducted on an inspection tour of the Army Aviation School and Heliport at Fort Eustis, Va., on April 16.

In an introductory talk, Col. William B. Bunker, Commandant of the Army Transportation School, defined the function of Army aviation. Briefly, the units are composed of tactical aircraft, used for artillery spotting and for laying telephone wires, and logistics aircraft, used for delivering supplies and troops to isolated units.

The members were shown through the Mechanics' Training School by Major Koloski and Major Dodson. Courses cover the repair of air frames and engines, instrument and electrical work, the operating principles and repair of fixed-wing aircraft and helicopters, and the training of officers. At the Air Transportability School, officers in all branches of the Army are taught the theory and practice of loading transport planes, using full size mock-ups.

The visiting engineers saw a flight demonstration, at Felker Heliport, which included autorotation, the hauling of loads, and wire laying.

Indianapolis Section

Paul F. Ferreira, Jr.
Secretary

Two motion pictures were shown at the April 12 meeting of the Indianapolis Section in the Indiana World War Memorial Building auditorium. *The Questioning Mind* dealt with the thinking that occurred before great strides in science were accomplished. *We Saw It Happen* was a documentary film on man's attempts to fly.

A Nominating Committee composed of Harold DeGroff, Russell S. Hall, and Roger W. Merriman has recommended a slate of officers for election at the next meeting.

Los Angeles Section

Joseph W. Wechsler
Secretary

Five hundred members and guests of the Los Angeles Section filled to overflowing the auditorium of the Institute's Western Headquarters Building on Monday evening, April 11, to hear Theodore von Kármán, HFIAS and Director, AGARD, speak on "Solved and Unsolved Problems in High-Speed Aerodynamics." Additional interest in this special meeting was created by the prepared comment of Allen E. Puckett, Head, Missile Aerodynamics Section, Hughes Aircraft Company; Kermit E. Van Every, Chief, Aerodynamics Section, Douglas-El Segundo; and Hans W. Liepmann, Professor of Aeronautics, California Institute of Technology. All four speakers were introduced by the guest chairman, Wolfgang B. Klemperer, Research Engineer, Douglas-Santa Monica. Warren Dickinson, Section Chairman, presided at the meeting.

After indicating that he would confine his presentation to "external" aerodynamics (the motion of bodies through fluids rather than the motion of fluids through compressors, turbines, etc.), Mr. von Kármán further established the context of his talk by defining a solved problem as one to which the straightforward application of present knowledge can provide an answer. In contrast, a workable answer in the area of an unsolved problem requires mathematical skill and/or an intuitive "flash." The most general cleavage that he established between solved and unsolved problems was in the observation that linearized theory may be considered to be fundamentally solved, whereas problems to which linearized theory cannot be applied are thought of as unsolved. In a more specific vein, he cited transonic and hypersonic speeds as two regions where mathematical skill has not been successful in providing solutions. In the former, the difficulty is connected with the fact that the domain of supersonic flow, and hence the shape of the mathematical solution, changes from one speed to another. For the latter, the main stumbling block has been the need to account for viscous effects. Since the paper will appear in full in the forthcoming *Centenary Book* of the Brooklyn Polytechnic Institute, it is not discussed in further detail here.

The prepared comment was of special interest at this meeting, since it disclosed the views of some of the most prominent aerodynamicists in the Los Angeles area on the subject of which problems of high-speed aerodynamics are most in need of solution. Mr. Puckett stressed the need for more reliable methods of determining the range in which linearized theory can be applied within the limits of engineering accuracy; he noted that there was room for some extremely simple experiments that would be helpful in fulfilling this need. Mr. Van Every's chief concern was with problems of separation—e.g., buffeting, boundary-layer buzz, and inlet-duct rumble. He, too, mentioned the need for much more experimental work.

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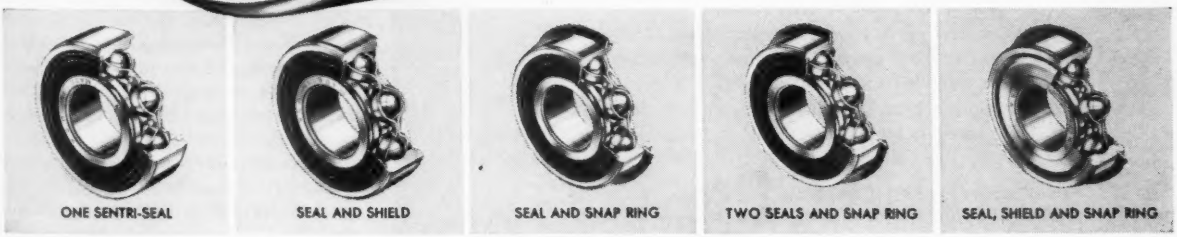

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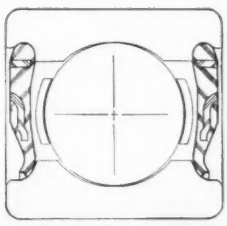

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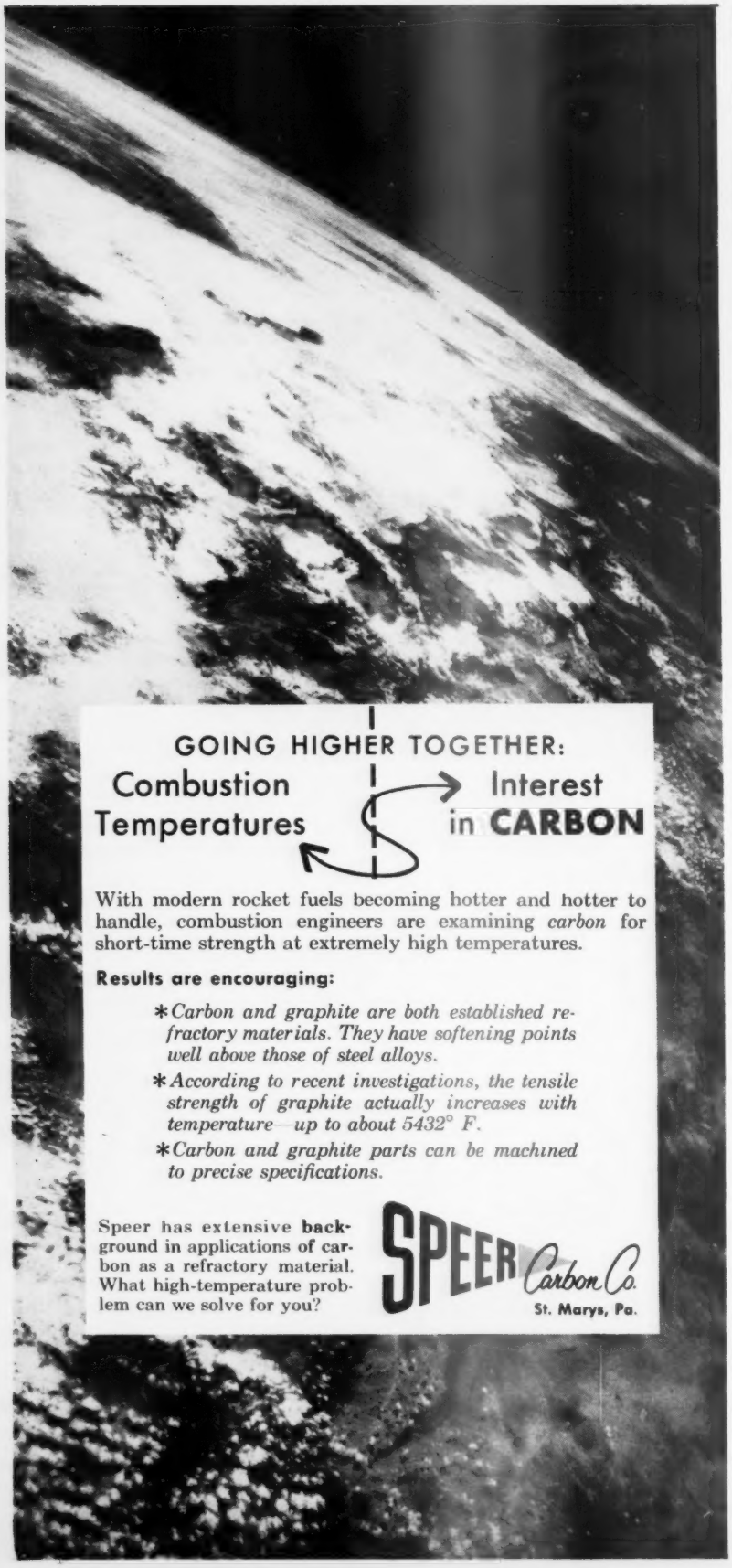
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Mr. Liepmann dwelt on some of the problems of carrying out experimental testing at high speeds. He noted that the difficulty in matching Mach Number, temperature, viscosity, and other basic factors in wind-tunnel testing has resulted in a situation in which aerodynamic testing is becoming more and more analytical.

▶ In an address entitled "A Systems Approach to Science, Technology, and Education," delivered at the April 21 dinner meeting of the Los Angeles Section, Ralph E. Gibson, Director, Applied Physics Laboratory, The Johns Hopkins University, made use of some of the ideas evolved during the development of complex and automatic systems to provide an insight into the actions and interactions which characterize modern science and technology and our educational system. Mr. Gibson was introduced by L. A. Hyland, Vice-President and General Manager, Hughes Aircraft Company. The meeting, which attracted 85 members and guests in spite of inclement weather, was presided over by Warren Dickinson, Section Chairman.

Mr. Gibson showed how science, technology, and education each have the basic characteristics of a system—i.e., an assemblage of interacting elements designed to carry out some predetermined function in a stable manner. In the case of science, the observation of nature and the urge to know are incentives that stimulate the activities of pure research which, in turn, yield the products of science, understanding, and satisfying patterns. These products, in their turn, facilitate the further observation of nature and stimulate the urge for additional knowledge so that the system is stable and tends to increase in both magnitude and scope. The basic system characteristics of technology are the needs of society (incentive), development and engineering (activities), and commodities and implements (products). Here, too, the products result in increased incentive, since the needs of society (or at any rate the supposed needs) are strongly influenced by the commodities and implements already possessed.

Education also possesses these system characteristics. The incentive is the need to prepare people for positions of usefulness and leadership in our society (including, of course, science and technology), the activities are the schools and universities, and the products are the leadership and other capabilities provided. The regenerative nature of this system is implicit in its relationship with other systems in our society such as the two described earlier.

In conclusion Mr. Gibson emphasized the salient relationships among science, technology, and education. Used as a whole, this system is the most powerful means of expanding knowledge in the

Niagara Frontier officials talk with Joseph A. Shortal, Chief of the Pilotless Aircraft Research Division, Langley Aeronautical Laboratory, NACA. *Left to right:* George B. Melrose, Chairman, Niagara Frontier Section; Mr. Shortal, speaker at the April meeting; and Waldemar O. Breuhaus, of Cornell Aeronautical Laboratory, Program Chairman of the meeting.

history of man. He described our educational system as a marginal component because of its emphasis on the number of people trained rather than on the quality of the training.

As a result of this last point, the question period with which the meeting was concluded was primarily devoted to the problems of improving our primary and secondary education systems.

Richard Boyles
Member, Specialist Meetings Committee

"Nonlinear Problems in Structural Analysis" was the subject of a talk by Paul H. Denke, Strength Analysis Methods Engineer, Douglas Aircraft Company (Santa Monica), at a Los Angeles Section specialist meeting held on April 26. Attendance at this highly specialized lecture was 30.

Mr. Denke indicated the need to account for plasticity in determining the load distribution in statically indeterminate structures. The development of automatic computing machinery has made this possible through use of a method based on the matrix formulation of the Maxwell-Mohr continuity equations. General nonlinear load and deflection equations, with an iterative form for their solution by the Newton-Raphson method, were presented. The analysis of a simplified swept-wing structure served to illustrate the effect on load distribution of accounting for the plastic behavior of the structural members.

Edward F. Versaw
Member, Specialist Meetings Committee

At an April 12 specialist meeting attended by about 70 members and guests of the Los Angeles Section, Winfield H. Arata, Jr., Chief Sales Engineer, Aircraft Division, Fairchild Engine and Airplane Corporation, spoke on "Design Considerations for Cargo Aircraft." Mr. Arata based his remarks primarily on experience gained on the C-130 "Hercules" project in his previous position as Preliminary Design Group Engineer with Lockheed Aircraft Corporation.

Mindful of the air-line operators' problems, Mr. Arata confined his presentation primarily to an analysis of cargo handling related to air-frame design. To reduce tariff rates, thereby attracting additional markets, he recommended the following design features: loading entrances that permit full utilization of the fuselage cross section, cargo floors at truck-bed height which are also strong enough to support wheeled vehicles, flush internal tie-down fittings, an integrated pallet system, and turboprop power plants.

Niagara Frontier Section

Clifford L. Muzzey, *Secretary*

The Niagara Frontier Section was fortunate to have Joseph A. Shortal of the NACA as the speaker at its April meeting. Walt Breuhaus, Assistant Head of the Flight Research Department, Cornell Aeronautical Laboratory, was in charge of the program and introduced the guest speaker. Mr. Shortal is Chief of the Pilotless Aircraft Research Division of the NACA Langley Laboratory, perhaps better known as the Wallops Island facility. His subject was "Techniques of Model Testing in Free Flight."

The Wallops Island rocket firing range provides a means for testing which fills a gap between the wind tunnel and full-scale free flight. The division has been in operation for 10 years, and during that time it has conducted around 3,000 "firings." The test technique today uses one or more solid-fuel rockets to accelerate a dynamic scale model of an airplane or missile, or a specially designed "aerodynamic shape," up to the desired speed. Most models hit transonic or supersonic speed. Many have boosters as well as internal rockets. After the booster rocket burns out, the booster section falls away, and the model spurts ahead as its internal rocket is ignited. The model's flight path is observed by radar and optical means, and local measurements of forces, pressures, etc., made at the model are telemetered back to the ground station.

Early procedure was simply to drop a dense model from an airplane, letting it accelerate by gravity. Mach Numbers of 1.2 were reached with the drop models, but the rocket-boost method permits attainment of Mach 5 on certain models.

The work, Mr. Shortal declared, is directed primarily at measurements of drag, control effectiveness, and stability parameters. Secondary in emphasis have been tests for flutter, ram-jet performance, and aerodynamic heating.

Some of the special problems faced by the model testers are air-borne instrumentation that will withstand 40g's during launching, design of telemetering antennas tailored to each new model, dynamic stability of the booster and model both separately and in conbination, and the accurate alignment of the thrust axis and center of gravity for the launching configuration. To these are added the difficulties of transportation to the remote test area and the problem of clearing the overwater firing area of local fishermen who have developed a fatalistic attitude toward the test models over the years.

The talk was illustrated with slides showing instrumentation systems and certain test results and with a color movie of a number of model launchings. The questions and discussion from the floor attested to the interest in Mr. Shortal's talk, which was greatly appreciated by the officers and members of the Niagara Frontier Section.

St. Louis Section

L. A. Smith, *Secretary*

A panel discussion of structural fatigue problems in airplane and helicopter design occupied 170 members and guests at the March 23 meeting of the St. Louis Section, held jointly with the American Helicopter Society.

Chairman Edward M. Flesh outlined the topic in his opening remarks, and Roy Priest introduced the following speakers: John H. Meyer, Chief of

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Panel members shown during a discussion of fatigue problems at the March 23 meeting of the St. Louis Section. From *left to right*, around the table, are John H. Meyer, Neal McKinsey, Kurt H. Hohenemser, H. J. Grover (moderator), Albert J. Kullas, Richard G. Bowman, and A. A. Lischer.

Structures, McDonnell Aircraft Corporation; Albert J. Kullas, Supervisor, Structural Design Section, The Glenn L. Martin Company; Richard G. Bowman, Assistant Chief Engineer, Republic Aviation Corporation; Neal McKinsey, Chief Design Engineer, Bell Aircraft Corporation; A. A. Lischer, Chief of Helicopter Structures, McDonnell Aircraft Corporation; and Kurt H. Hohenemser, Chief of Aerodynamics, Helicopter Division, McDonnell Aircraft Corporation. The moderator was H. J. Grover, Chief, Applied Mechanics Section, Battelle Memorial Institute.

Mr. Grover opened the discussion with a definition of fatigue problems of today's materials, outlining the basic factors of the phenomenon of decreased resistance of a material to cyclic stress.

Mr. Kullas presented the basic parameters that establish airplane design stress levels for a given airplane life. These are established by studying the component anticipated load history throughout the life of the airplane and establishing a working *S-N* curve.

Mr. Bowman described some interesting fatigue failures that have occurred. These appeared to result from local structural discontinuity creating high stress regions. The fixes for this type of failure usually require major redesign. Slides were shown to supplement the discussion.

Mr. Meyer showed slides and described an analytical approach to establish scatter with a limited number of test units.

Mr. Hohenemser exhibited a movie showing the motion of a helicopter blade during the cycle. The camera had been mounted on the hub and aimed toward the end of the blade so that the pictures showed deflection about both axes.

Mr. McKinsey emphasized that fatigue design today requires more effort than strength design in helicopter engineering. He said most design parameters are arbitrary in the effort to achieve a reasonable life. Fatigue elimination means attention to detail design.

Mr. Lischer reviewed the criteria for basic fatigue design in helicopters, emphasizing that known phenomena can be controlled in design. Extensive test programs and experimental work on new manufacturing processes, now in progress, are expected to lengthen fatigue life.

San Diego Section

D. P. Germeraad
Acting Corresponding Secretary

The San Diego Section's Student Aid Program is making good progress. The IAS Student Branch at San Diego State College, organized under our auspices, now has 28 members and has elected officers. Speakers have been obtained from the parent Section. Convair ran a plant tour for the students this spring.

The Student Aid Committee cooperated with the San Diego Engineers' Council in furnishing speakers for high school "career" conferences. A Science Fair display was set up in the IAS Building in April. The Section is cooperating with the Board of Education on an aviation program for television.

▶ On May 5, R. L. Chapman, Dynamics Engineer, Convair-San Diego, addressed the Section on "Hydraulic Control System Simulation." Discussion centered primarily on Convair's experience with hydraulic control system simulation for a delta-wing airplane and some of the unique features required for the delta-wing configuration. The requirements of the system and changes to the system in the three modes of airplane control were disclosed. Three methods of simulation were described in detail—namely, analytical, laboratory testing of the full-scale system, and ground testing of the airplane.

▶ The April 12 meeting on "Space Flight Problems," with Krafft Ehricke as the speaker, proved to be another outstanding meeting of the year. This was the second of a series of four talks on this subject and was devoted mainly to the aspects of high-speed flight in the upper and the outer atmosphere, including global circumnavigation. Mr. Ehricke also covered in detail the development phase leading up to man's technological and physiological capability of establishing manned satellites outside the relevant atmosphere.

San Francisco Section

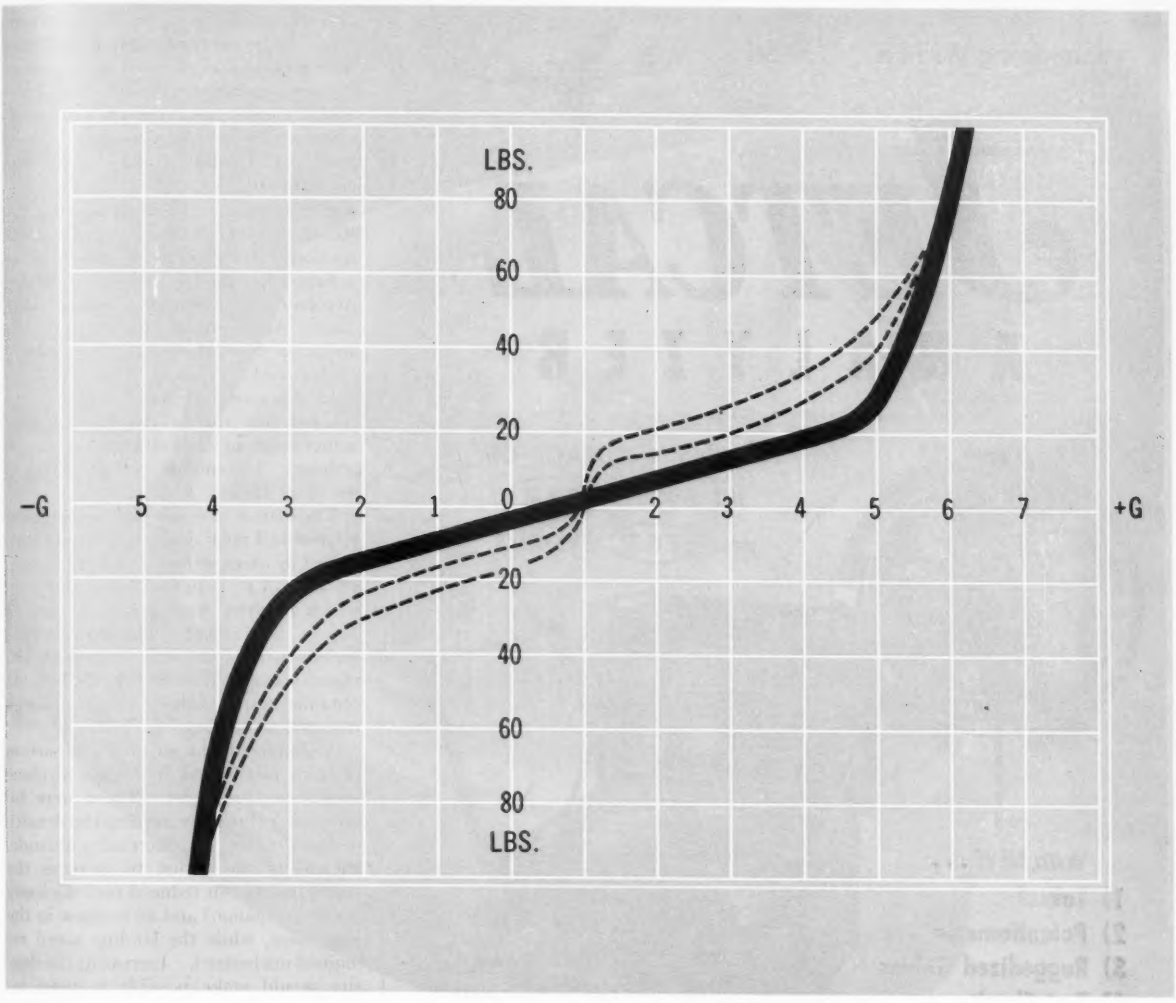
George E. Cooper, *Secretary*

At a classified meeting sponsored by the Air Research and Development Command, USAF, Norman C. Ruel, of North American Aviation, Inc., spoke on "Large Rocket Engine Development." The meeting was held April 21 at Stanford University.

▶ The San Francisco Section's monthly dinner meeting on March 31 featured a talk on "Aircraft Evacuation" by Ira E. Thatcher, Safety Engineer of United Air Lines, Inc. The discussion dealt with the methods and the research pursued by United in an attempt to determine and solve the problems of evacuation of an air liner in an emergency.

The first phase of this work was carried out by Cornell Aeronautical Laboratory under a research contract with United Air Lines. For this study a varied group of people, selected from 300 volunteers, were told only that they were going to participate in a program designed to aid flight safety. They were given a sightseeing flight around the Buffalo-Niagara Falls area before being told that they were to make an emergency landing and a rapid evacuation of the airplane was necessary. The plane was brought in for a normal landing but halted in a predetermined spot where a battery of cameras in and out of the airplane recorded the unrehearsed emergency that followed. From this and other studies, the present seating and aisle arrangement and the optimum crew utilization were determined.

A film was shown to explain the training that is given all U.A.L. flight crews in ditching at sea. Problems confronting such an emergency were discussed, and the need for complete training of the crew became apparent. The problem of wind drift emphasized the need for having life rafts secured to the airplane until loaded and for keeping them tied together until the personnel loads and supplies were balanced. Actual loadings and launchings of life rafts were shown, as well as simulated rescues by the Coast Guard. These shots, incidentally, provided an opportunity to view the smooth, efficient operation of



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this organization. The talk was well spiced with personal experiences taken from some of the crew training programs. Those attending this meeting came away with the feeling that the survival chances of passengers had been greatly enhanced by U.A.L.'s research and by thorough crew training.

▶ The February 24 dinner meeting had Robert T. Jones of the NACA as guest speaker. Mr. Jones, who was elected a Fellow of the IAS in January, is an Aeronautical Research Scientist with Ames Aeronautical Laboratory. He spoke on the "Possibilities of Efficient High-Speed Transport Airplanes."

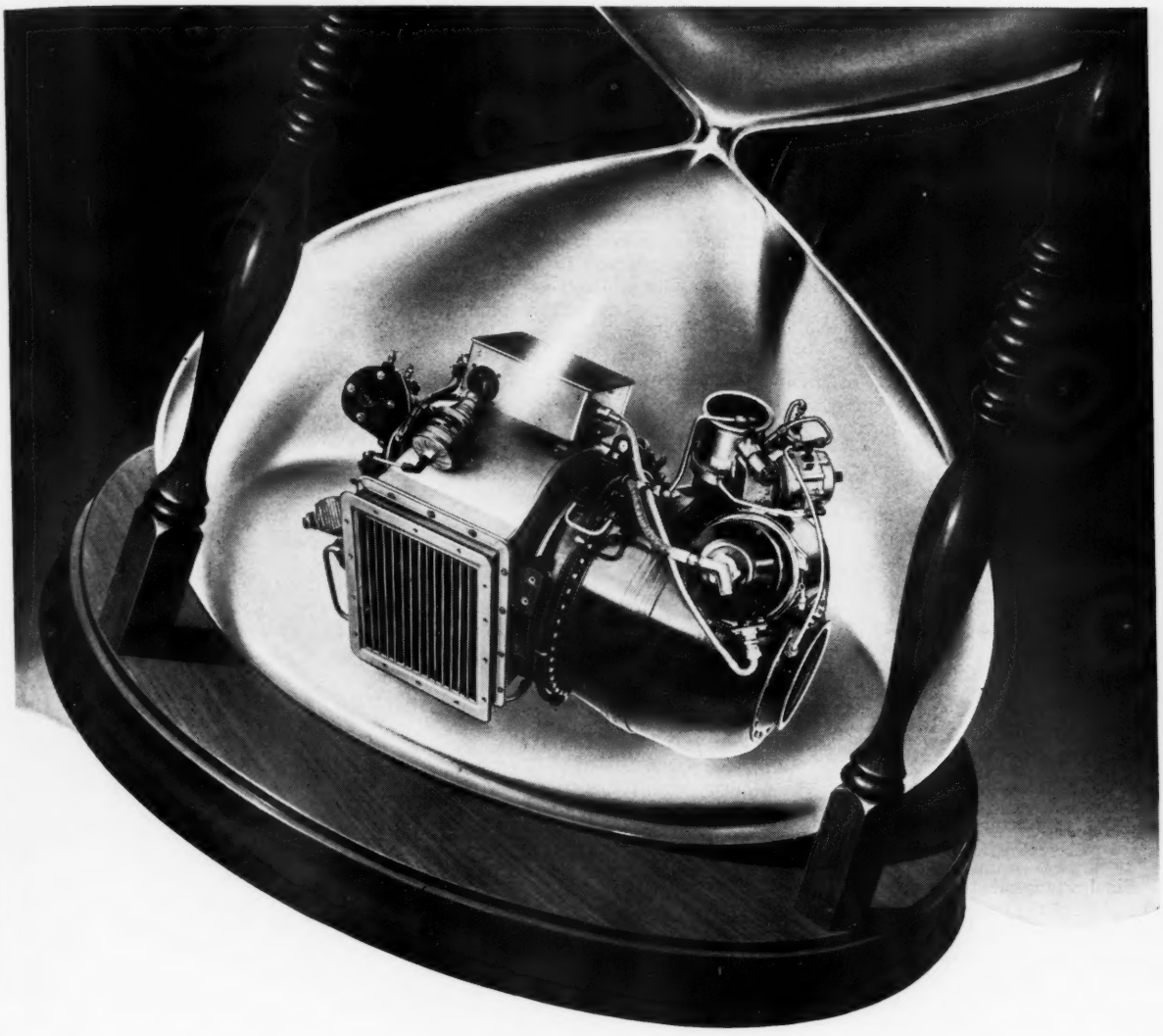
In discussing airplane efficiency, he pointed out that a modern air liner achieves about the same mileage as an ordinary automobile while traveling six times faster.

The extent to which early experiment approached ideal dragless flow was illustrated by an experiment of E. N. Jacobs at NACA's Langley Laboratory in which an airfoil having an L/D ratio of 300 to 1 was tested. The trend toward higher aspect ratios in transport airplanes was said to result from the benefits obtained from a reduction in the energy required for propulsion.

A simplified but striking comparison of three methods of increasing airplane speed was presented. These were by increasing thrust, increasing the density of the airplane, and increasing altitude. Increasing the thrust to increase the speed resulted in reduced fuel efficiency (miles per gallon) and an increase in the gust force, while the landing speed remained unchanged. Increasing the density would make possible a speed increase without additional thrust. Fuel consumption would remain the same while the gust force would be reduced, but the landing speed would be increased. Increasing altitude appeared to offer the most from this type of analysis, in that to achieve the same relative speed increase, thrust remains the same, as does fuel consumption (in miles per gallon) and the landing speed. In addition, the gust force would be reduced.

Mr. Jones stated that he had made calculations that indicated that if the means were available, a climb as high as 80,000 ft. would save time on a flight as short as 500 miles. An interesting comparison was made by taking a small cab-type airplane with an L/D ratio of 15 to 1 and a cruising speed of 100 m.p.h. and assuming that a thrust of slightly more than 1/15 the weight could be supplied at any altitude. At 40,000 ft. the plane's speed would be 200 m.p.h., while at 68,000 ft. it would be 400 m.p.h.

In discussing high-speed flight, Mr. Jones disagreed with the theory that wings must become proportionately smaller. If the economy of propulsion is to be a major factor, he believed that the relative proportion of wings will not



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diminish, even at supersonic speeds. Wave drag at supersonic speeds will require a marked change in airplane form when economy of flight is considered. As a final means of attaining low drag and very high L/D ratios, Mr. Jones presented a truly fascinating design in the single oblique elliptical wing. This might be conceived as a single straight wing for take-off and landing which would then be flown in an extreme yawed condition, lacking bilateral symmetry but giving terrific L/D ratios.

Twin Cities Section

H. C. Johnson, *Recording Secretary*

The March 10 meeting of the Twin Cities Section was held in Murphy Hall at the University of Minnesota, with members of the Student Branch as guests.

Chairman Robert Hoel introduced the speaker of the evening, R. Richard Heppe, head of the Aerodynamics Department of Lockheed Aircraft Corporation. Mr. Heppe spoke on "Current Aircraft Design Problems." He introduced his subject by comparing present-day subsonic fighter aircraft with future high-performance aircraft and described several of the problems that occur at extremely high velocities. Using slides, Mr. Heppe pointed out why razor-thin airfoils and elongated fuselages are necessary to reduce drag to tolerable limits. He also discussed structural problems associated with thin wings. Thick skins combined with multispar arrangements will be used to achieve strength, he said, although permissible g loads will be lower than contemporary practice allows. Extremely high velocities will require the use of evaporative cooling for pilot protection during combat portions of a mission.

Two films were shown. One illustrated the necessity for structural rigidity at high Mach Numbers; the other demonstrated current Lockheed designs, including turboprop transports and vertical-rising interceptors. A short question period followed Mr. Heppe's presentation, in which the relative merits of swept and straight wings were compared.

Student Branches

Academy of Aeronautics

Joseph Jagiello
Corresponding Secretary

Final arrangements for a field trip to the plant of the Piper Aircraft Corporation, at Lock Haven, Pa., were made at our meeting of April 27. The trip was set for May 3, with an alternate date of May 5 in the event of bad weather. Because of the distance involved, the members decided to make the trip by air, in private or rented light planes.

A film entitled *Survival Under Atomic Attack* was shown at this meeting. It pointed out the various dangers confronting a civilian and the precautions.

Georgia Institute of Technology

Robert E. Drowns, *Secretary*

Glenn Gray, retiring Chairman, presided at the May 2 meeting of the Georgia Tech Student Branch. It was held in the Aeronautical Engineering Building with 32 members present. New officers were elected for next year, as follows: Roland Fuentes, Chairman; James May, Vice-Chairman; Robert Drowns, Secretary; and Ralph Eden, Treasurer.

After the business session a film, *The Hell-Diver*, was shown. Made in 1944, it was an excellent film presentation of the performance characteristics of the airplane. Included in the film was a discussion of pay load, endurance, speed, maneuverability, instruments, structure, safety devices, rate of climb, and stall and dive characteristics. Along with the performance presentation, the film showed how to fly the plane and the operations that a pilot must perform prior to and during flight.

Illinois Institute of Technology

Merrill J. Foote
Corresponding Secretary

John Everett, newly elected Chairman of the Illinois Tech Student Branch, called the meeting of April 29 to order. The other new officers were installed: Ken Hudson, Vice-Chairman; Charles Ruby, Treasurer; Bob Borger, Recording Secretary; and Merrill Foote, Corresponding Secretary.

Gary Theis and Lou Rubenstein were appointed Chairmen of the Membership and Publicity Committees, respectively.

"High-Speed vs. Low-Speed Aircraft" was the subject of a panel discussion by Captain Taylor and Lieutenant Ramsted, with Lieutenant (j.g.) Lowheid as moderator. Captain Taylor described the advantages of moderate-speed airplanes, while Lt. Ramsted interpreted the ability of jet aircraft.

Iowa State College

Robert Dighton, *Secretary*

Two seminar reports were read at the April 6 meeting. Arden Boyd presided.

Jim Bone reported on bending tests that he had run on corrugated aluminum, and John Midgordon reported on torsion tests that he had run on corrugated aluminum. The specimens used in both of these bending and torsional tests were identical. For both tests, 24ST aluminum sheets 0.025 in. thick were riveted to standard corrugated 24ST aluminum sheets, also 0.025 in. thick. For both the bending and the torsion tests, two sets of three types of specimens were used. In one set, 2-in. rivet spacing was used, and in the other set 3-in. spacing was used. Included in each set were specimens having three, six, and nine corrugations.

Mr. Bone ran his bending tests on an Olsen testing machine. He found that the specimens failed by buckling and that the specimens with 3-in. rivet spacing were stronger than the ones with 2-in. spacing.

Mr. Midgordon ran his torsion tests on a device that held one end of the specimen fixed while the other end was rotated. The rotation of certain points was then measured. He found that the specimens failed by buckling. These failures were at some angle that varied very little, regardless of which type of specimen was being tested.

A movie *Wing Test* was shown of the procedure for conducting a test on a gull-type wing.

▶ The March 9 meeting of Iowa State was called to order by the retiring Chairman, Phil Smith. The following officers were elected for next year: Arden Boyd, Chairman; Murl Grandia, Vice-Chairman; Robert Dighton, Secretary; and Carl Anderson, Treasurer.

Chuck Wooldridge was elected Program Chairman; Glen Christoffersen, Senior Representative to the Engineering Council; and Carl Vollersen, Junior Representative to the Engineering Council. E. W. Anderson, Professor of Aeronautical Engineering and Mathematics, was named Faculty Adviser.

The program for the evening consisted of two motion pictures, *New Wings for the Navy* and *The Jet Story*. The first movie dealt with the Douglas F4D Skyray breaking the world's speed record in level flight. It covered the preparation of the Skyray for the test, the four passes of the jet over the desert course, and the calculation of the speed after the runs had been completed. The movie also showed some of the equipment used in a speed test of this type and how it was operated.

The Jet Story followed the development of the jet engine in the United States. It started with the importation of the first jet engine from England, followed rather closely the manufacture of the first American jet engine by General Electric Company, and then traced the development of jet engines up to the present models

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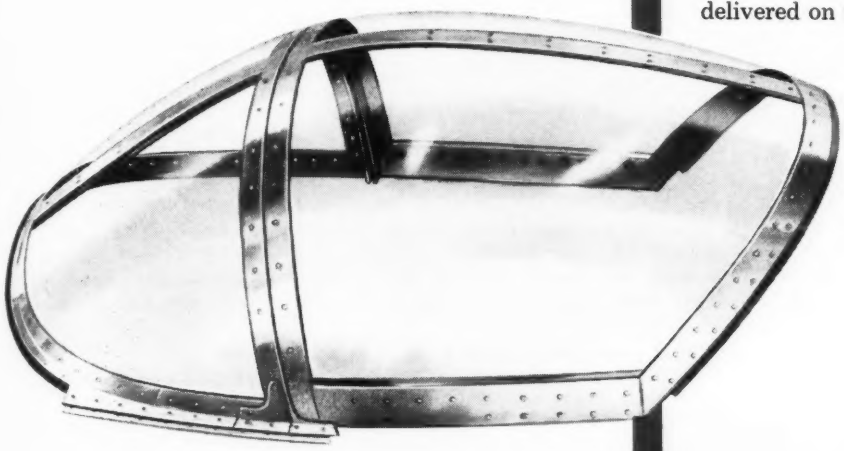

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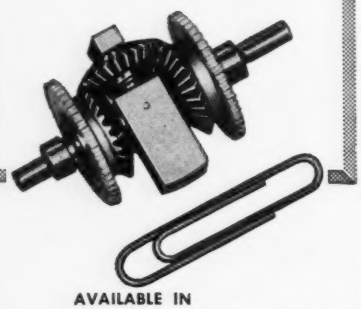

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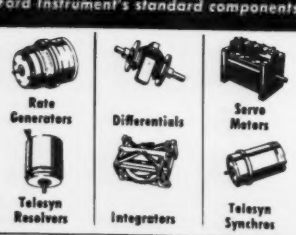

Oregon State College

L. G. Malcom, *Vice-Chairman*

The Oregon State Student Branch met on April 20. Chairman Harry Reeder opened the meeting with a discussion of the regional IAS Field Trip scheduled for May 10–14 in Los Angeles. Out of 20 members present, twelve decided to go on the trip. A visit to Ames Aeronautical Laboratory is planned on the way down.

The following officers were elected for next year: Vic Peterson, Chairman; Larry Malcom, Vice-Chairman; Lyle Hylen, Secretary; Al Van Dyne, Treasurer; and Harm Buning, Faculty Adviser.

The annual IAS spring picnic at Avery Park turned out to be a great success. After lunch we had a model airplane contest with prizes for planes that stayed up the longest.

Polytechnic Institute of Brooklyn

Ernest G. Riesenfeld, *Treasurer*

Twenty members of the Brooklyn Poly Student Branch visited Picatinny Arsenal, near Dover, N.J., on May 7. The field trip was under the auspices of the American Rocket Society.

After a welcoming address by Col. J. A. Barclay, Commanding Officer of the Arsenal, the meeting was opened by C. W. Chillson, President of the New York Section of ARS.

Roy Wood, Chief of Ammunition Development Lab A, spoke on "Rocket and JATO Design and Development at Picatinny Arsenal." This talk included a brief history of military rockets, including the Nike and Honest John. Slides were shown to explain the 2.36-in., 3.5-in., and 4.5-in. rockets and the JATO units developed at Picatinny.

Guede Coglan, Curator of the Arsenal Museum, gave an advance description of the tour. At the rocket test range we heard a lecture on the manufacture and use of the different rocket fuels and JATO units. Another talk covered the use of electronic equipment to record data while rockets are being tested. This half of the tour ended with an inspection of the test cells.

After lunch, we visited the museum. Its interesting collection of past and present ordnance supplies includes drawings, photographs, and actual samples or replicas of almost every type of U.S. Army ammunition, as well as hundreds of types used by other countries. There were full-scale models of the Honest John, Nike, and World War II block busters. A color film was shown on the testing of JATO units. This included normal and abnormal firings in the Picatinny test cells.

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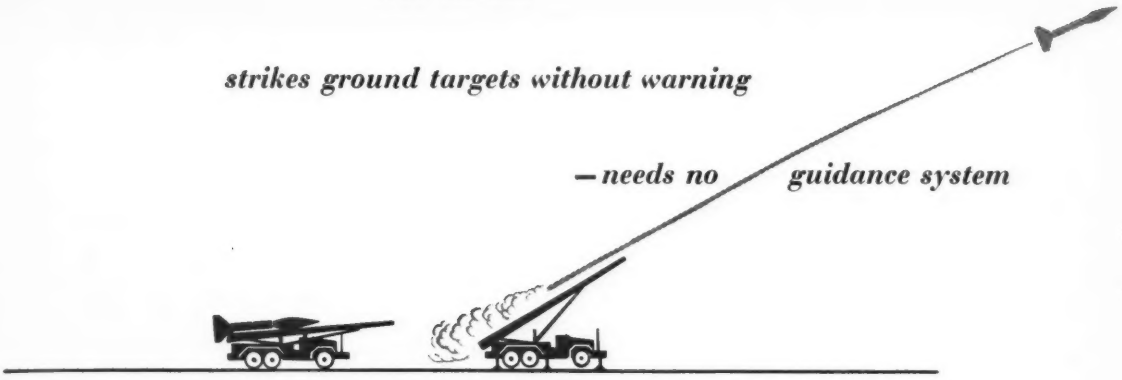

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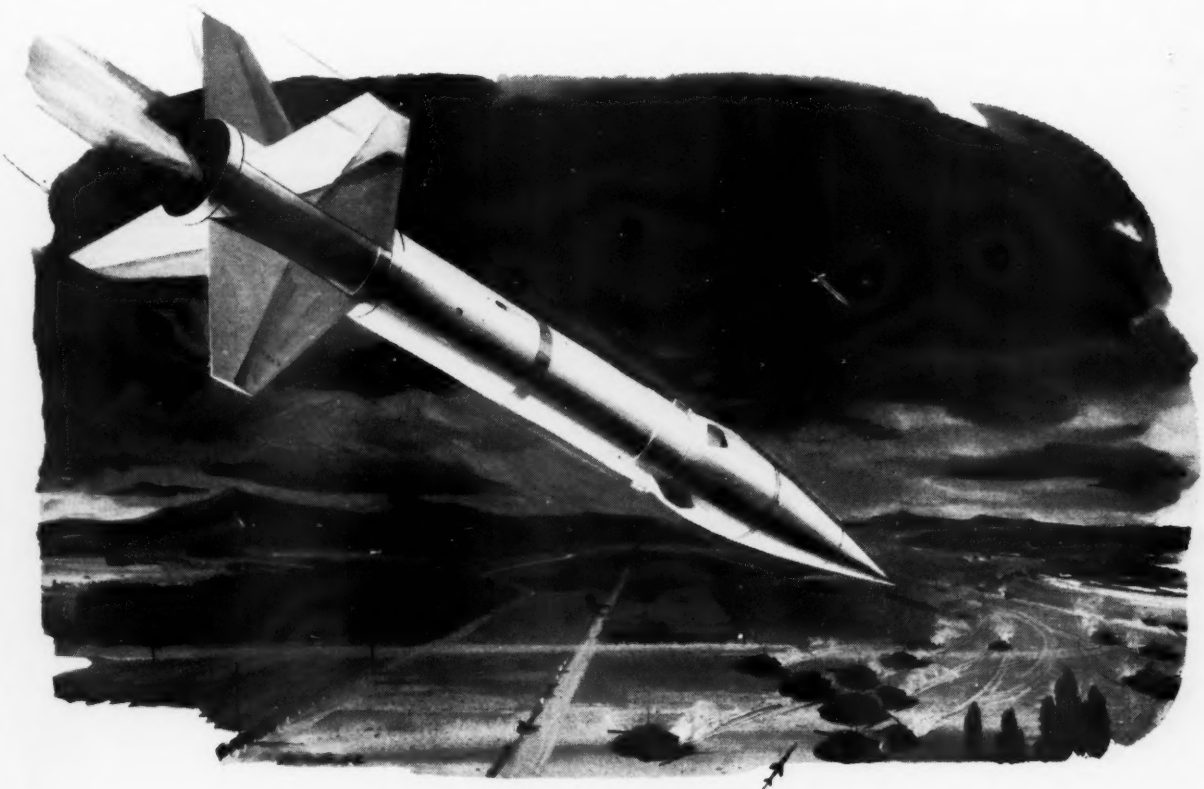

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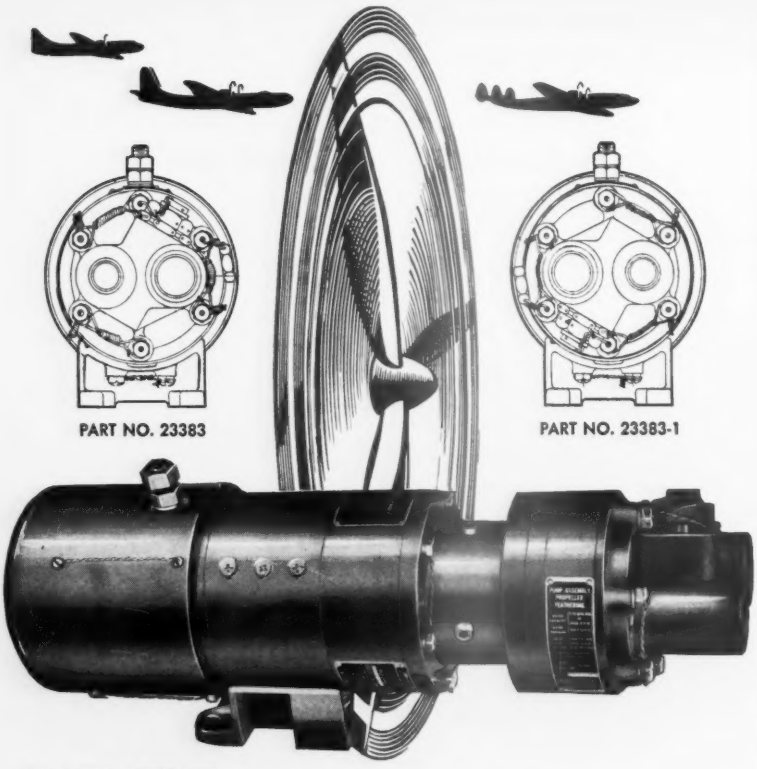

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Rensselaer Polytechnic Institute

Richard C. Kennedy, *Secretary*

The R.P.I. Student Branch held its last business meeting of the year on April 20. After the business session, Chairman Robert Whitten introduced William Peck, of the engineering staff of Piasecki Helicopter Corporation, who spoke on the development, engineering problems, and future of the helicopter.

In the industry, Mr. Peck said, it is generally felt that the helicopter has unlimited possibilities. There are many applications in which it will be definitely superior to both the "flying platform" and VTO plane. Vibration and noise have been important objections, he added, but with continued technical development the helicopter will be the rule rather than the exception. At the end of his talk, Mr. Peck showed several films illustrating how Piasecki helicopters have been put to use in military and commercial applications.

Congratulations are in order for Wilbert Lick, who has won the Student Branch Scholastic Award. In addition to maintaining a nearly perfect scholastic average, Willie has been the mainstay of the football and lacrosse teams during his 4 years at the Institute.

U.S. Naval Academy

C. M. Charneco, *Vice-Chairman*

Officers for next year were elected at the March 25 meeting of the Student Branch at the U.S. Naval Academy. C. M. Charneco, Jr., was named Chairman; H. L. Mooney, Vice-Chairman; W. S. Peters, Program Director; and J. E. Johnson, Secretary-Treasurer. Chairman A. G. Cicolani presided.

Midshipman H. L. Mooney won first prize in the annual technical paper contest held March 31. Midshipman W. S. Peters was second. Midshipman Mooney went on to win first prize with his paper at the Southeastern Regional Conference for Student Branches conducted by the IAS at Virginia Polytechnic Institute.

Mr. Ray, of The Glenn L. Martin Company, spoke at the meeting of April 15. He discussed Martin's XP6M Sea Master and the advantages of future water-based aircraft.

University of Colorado

Harold J. Bartleson, *Secretary*

Officers for next year were elected at the April 26 meeting of the University of Colorado Student Branch, held in the Aeronautical Engineering Building with 24 members present. Harvey Gerhard presided.

The new officers are Paul Lord, Chairman; Jim Patton, Vice-Chairman;

Harold Bartleson, Secretary; and Dick Hueholt, Treasurer.

Plans were made for the spring picnic to be held Sunday, May 29.

Two of our members attended the Texas Section's Third Annual Southwestern Student Competition in Fort Worth in April. Paul Lord won second prize with his paper on "Rocket Nozzle Testing with High-Pressure Air." Bill Oliver presented a paper entitled "Pure Metals."

University of Illinois

James H. Baker, *Secretary*

The University of Illinois Student Branch held its fifth meeting of the semester in the Electrical Engineering Building on May 4.

Andy Byrnes, of North American Aviation, Columbus, Ohio, gave a talk on "Aerodynamic Problems of Mach 1 Navy Fighters" and showed two short movies of taxi and flight tests of the FJ-4 Fury and a color film on carrier operations of the AJ-2.

Of particular interest was the inboard location of the ailerons on the FJ-4 and the low-speed problems arising from the consequent reduction of the flap area. Mr. Byrnes showed in slides and sketches how the flap effectiveness was improved by a special flap arrangement of gates and shrouds for controlling the boundary layer.

Mr. Byrnes also described how the shift in center of pressure location through the transonic region introduced new control and stability problems that do not occur at lower Mach Numbers. Of interest, too, were a picture and description of the milled wing construction used to achieve a satisfactory thin wing of high strength for the FJ-4.

▸ On April 27, the University of Illinois Student Branch heard a talk by George Graff, Chief of Aerodynamics of McDonnell Aircraft Corporation. He was introduced by Faculty Adviser Harry H. Hilton.

Mr. Graff discussed the essential factors involved in the solutions of typical engineering problems in the aircraft industry. He said that one thing the new engineer should keep in mind is that the company is in business to realize a profit. When this is remembered, a person may come up with answers that appear to be based on intuition but are actually based on practical considerations.

Mr. Graff mentioned further that more often than not the best solutions are the results of applied common sense and judgment rather than of strict technical ability. He also stressed the importance of understanding the basic theory that the engineer is introduced to in the early part of his college studies. He said that too frequently the engineer is working for answers in college and studying theory afterwards, whereas the ideal process would be the reverse.

An interesting discussion followed, covering topics such as compressor surge, transonic stability problems, and the current shortage of engineers.

University of Michigan

Robert R. Jones, *Secretary*

The annual regional student paper contest was held in Ann Arbor, Mich., on May 12, with the University of Michigan Student Branch as host. The University of Detroit, Wayne University, and the University of Michigan were represented. The Chairman of the local Branch, Robert Lauer, was master of ceremonies. A dinner was served to the 60 faculty and IAS members attending from the three universities and was followed by the paper competition.

Dick Philips of the U. of M. presented his paper "The Bull Whip—The Poor Man's Sonic Boom," followed by Ron Pampreen, from the U. of D., who gave his paper entitled "Cascade Boundary-Layer Control." Voigt Hodgson from Wayne University concluded the presentation of papers with his entry on "Hydrofoils Applied to Sailcraft."

While the judges retired to make their decision, Mr. Locke of Wayne University gave a brief history of the competition. The judges awarded first prize to Voigt Hodgson, second to Dick Philips, and third to Ron Pampreen.

University of Oklahoma

Carroll E. Gregg, *Secretary*

Chairman Roy A. Campbell presided at the May 10 meeting of the University of Oklahoma Student Branch.

R. B. Jenny, Chief of Aerodynamics, Douglas Aircraft Company, Inc., Tulsa, Okla., spoke on "Functions of the Aerodynamic Group as Related to the Engineering Department." Mr. Jenny noted how little engineers and engineering students really know about what goes on in an Aerodynamics Group. He also brought to our attention the fact that an airplane is not merely designed to get off the ground but must also take off in a certain distance, carry a particular load, travel at a prescribed speed, and be able to cover a specified distance.

Following his talk, Mr. Jenny presented a film entitled *Nike for the Defense of America*. Another film, *The First Transitional Flights of the Navy XFY-1*, distributed by Convair, was also shown.

Mr. Comp presented the IAS Scholastic Award to William D. Leaf. Kenneth H. Barnes received the IAS Lecture Award.

Phil E. Fisher was elected to serve as Branch Chairman for the first semester of the school year 1955–1956. Other officers elected were: Vice-Chairman, Greg Hosterman; Secretary-Treasurer, Thomas B. Shoebotham; and St. Pat's Representative, Ralph Capshaw.

▸ Since the scheduled speaker was unable to attend our April 12 meeting, Chairman Campbell arranged for three films to be shown to the 26 members and guests.

The first film, *Rocket Review*, showed a series of rocket and missile launchings and speculated on the possibility of space travel. The other two films, *Aviation News, Volumes One and Two*, presented many of the domestic and foreign developments in aircraft.

Robert A. Patchett gave a report on the progress of the Open House Committee. He said that Douglas Aircraft, at Tulsa, and Tinker Air Force Base, at Oklahoma City, had both been contacted and probably would bring exhibits to the Open House.

University of Tulsa

Lloyd T. Richardson
Secretary-Treasurer

The last regular meeting of the University of Tulsa Student Branch for the school year was held May 6, with Don Boyd presiding. The following officers were elected for next year: Chairman, Gerald Stevens; Vice-Chairman, George Murray; and Secretary-Treasurer, Lloyd Richardson. J. C. Klotz will continue as the Faculty Adviser.

The first talk was presented by Gerald Stevens, the newly elected Chairman, who spoke on the use of bonding adhesives in modern manufacture, particularly in aircraft. Mr. Stevens said that the present-day bonding adhesives were first developed in 1951 because of the need for a faster and better bonding material. These presently used adhesives consist mainly of phenolic resin and a type of synthetic rubber called "Buna N." They differ from glue in that they form actual chemical bonds with the materials to be bonded. Mr. Stevens pointed out that because of the greater area actually in contact with the bonding material, the skins of airplanes would be able to withstand greater shear forces and therefore the skins could be made thinner. According to Mr. Stevens' information, the bonds were tested and found to exceed the required properties by 300 to 400 per cent for impact strength, 100 to 200 per cent for shear strength, and approximately 200 per cent for chemical resistance.

Besides being cheaper from the standpoint of application to subassemblies, these bonding adhesives make pressurization of occupied sections of aircraft easier by filling the cracks between

overlapping internal and external members which would ordinarily be left somewhat unsealed by rivets. In concluding, Mr. Stevens mentioned that in spite of their high adhesive as well as cohesive strength, these bonding materials allow a certain amount of flexibility and at the same time dampen vibrations. Therefore, with these superior qualities, the bonding adhesives would be used to a much greater extent within the next few years.

The second talk was given by outgoing Chairman Don Boyd, who spoke on titanium and its use in aircraft production. Mr. Boyd stated that the use of titanium in the aircraft industry was increasing greatly as a result of many improvements in its properties through proper alloying. Titanium ingots can now be purchased in most of the same forms as stainless steel but with a good deal of saving in weight. The use of proper shielding makes welding fairly easy now by eliminating some of the ease of contamination at high temperatures.

In ultimate tensile strength, some of the aluminum-chrome alloys of titanium rank with high-strength steel and well above aluminum-alloys. They are also highly corrosion resistant. Thus titanium is extremely useful in the aircraft industry and will be used on a wider and wider scale for production of parts requiring above average strength with as little weight as possible.

▶ At a luncheon meeting in the Student Activities Building April 25, the speaker was E. W. Robischon, Manager, Western Region, IAS. He was introduced by Chairman Boyd.

Mr. Robischon spoke on job possibilities for graduating aeronautical engineers. He informed the group that the two main fields were research and industry, and he pointed out that education does not stop with the termination of formal training. He also listed the three most important factors in successful engineering as the ability to analyze problems, the ability to get along with people, and initiative.

Having just attended the Third Southwestern Student Competition in Fort Worth, Tex., Mr. Robischon told the group his views on such conferences and their importance to the engineers in industry, as well as to the students who present papers.

In these papers, he said, it is original thought that counts rather than original research. Skill of presentation also is important. Through these, one can show what he knows to others who may be interested in what he knows. This proves that the important thing is not what you know or who you know but who knows what you know.

Mr. Robischon said that technical societies such as the IAS offer the engineer a chance to find someone who can fill his position, so that he can advance to one of higher importance. He also stressed the importance of building up the Student Branches and discussed ways of doing this. He indicated that probably the best way was to encourage greater attendance through well-planned programs and by splitting up the work among enough members to prevent burdening a few and to give many an interest. Then he held a short discussion on how one could sell himself and his ideas.

▶ The April 15 meeting at the University of Tulsa was presided over by Don Boyd and had an attendance of 13.

First on the agenda for the evening was a film showing the first transitional flight of the XFY-1, the Navy's new vertical take-off airplane. The title of the film was *The First Transitional Flight.*

The speaker was A. H. Hasbrook, Director of Aviation Crash Injury Research at Cornell University. Mr. Hasbrook's talk was on aviation safety, regarding number and placement of seats, placement of galley equipment, fire estinguishers, etc. He stated that if the articles mentioned were not

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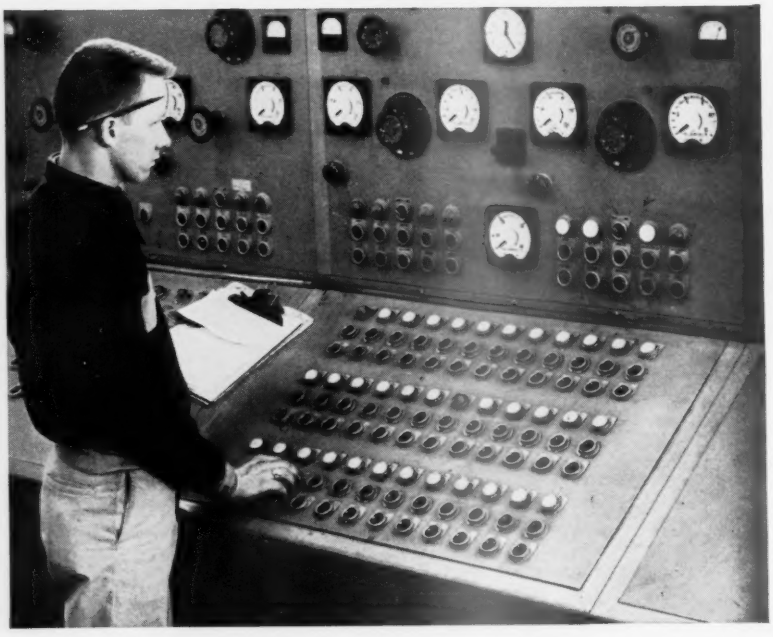

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placed properly or fastened securely that they would become missiles in the event of a crash and would cause more injury than the actual impact itself.

Mr. Hasbrook also spoke on the types of safety belt or harness to be used in aircraft. He also indicated that, because of the time-pressure tolerance of the body, the way the force is applied to the body determines to what extent a person is injured in a crash.

Mr. Hasbrook illustrated part of his talk with slides showing accidents and the resulting damage. At the end, he showed two unedited films of tests made with three Piper Cubs at varying velocities, ranging from 42 to 60 m.p.h. These tests involved crashing the Cubs into an embankment built to simulate the effect of a crash while in a spin.

University of Washington

Bud D. Nelson
Secretary-Treasurer

Vice-Chairman Allender presided at the meeting of April 13. The following officers were elected for next year: Bud D. Nelson, Chairman; Dale S. Jensen, Vice-Chairman; Gilbert L. Lee, Secretary-Treasurer; and Alfred C. Thomas, Corresponding Secretary. Plans were discussed for next year's Engineering Open House.

Two motion pictures were shown. *From Little Wings*, produced by Pan American World Airways, Inc., described flying model planes from the hobbyist's viewpoint. Special emphasis was put on weight-lifting free-flight models. *History of the Helicopter*, Produced by Shell Oil Company, depicted the early struggles to attain rotary-wing flight.

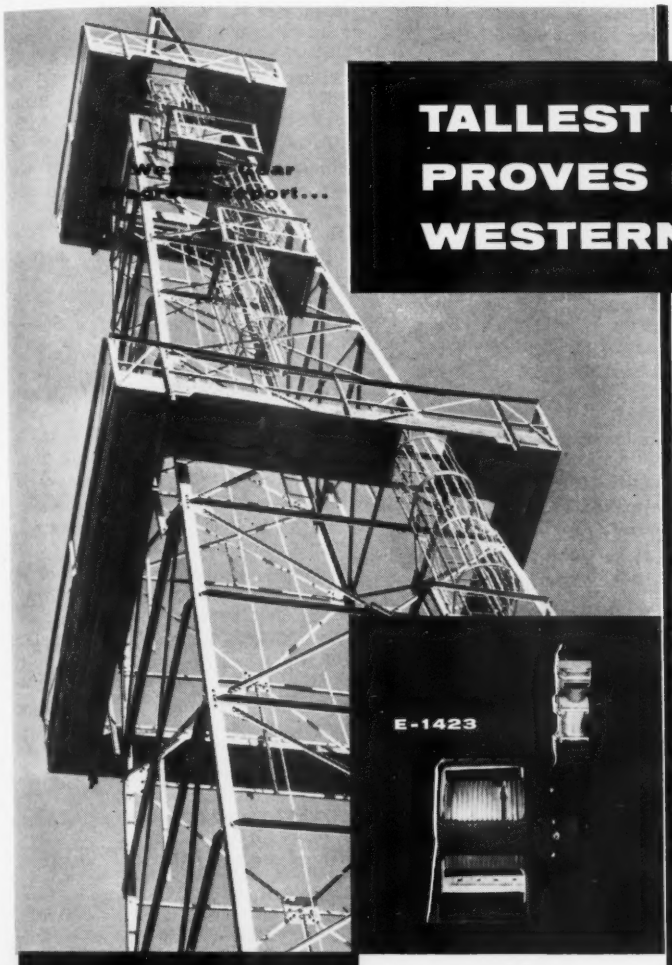
University of Wichita

J. F. Cox, *Secretary*

The University of Wichita Student Branch met in the Engineering Library on May 5 with ten members present and as many guests, including several members of the engineering faculty. Tom Lollar occupied the chair.

The principal speakers were Richard Ross and Don Hufford, who presented the papers they had entered in the IAS Third Southwestern Student Competition at Fort Worth, Tex. In his paper on "The Effects of Pressure Gradient on Boundary-Layer Parameters," Mr. Ross presented the results of several tests run in the University's 3-ft. wind tunnel to study the boundary layer surrounding an airfoil.

Mr. Hufford's paper dealt with the subject, "A Method for Simultaneously Increasing the Lift and Decreasing the Drag of a Conventional Airfoil Section."



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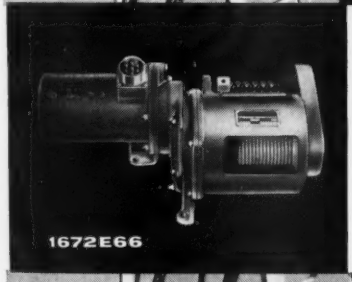

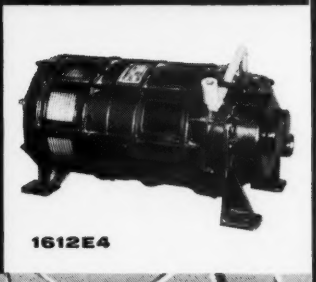

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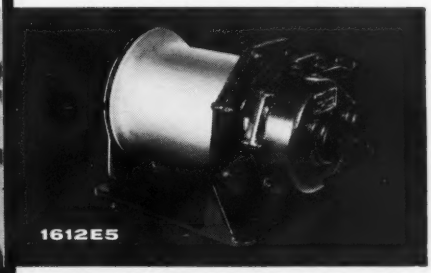

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His experimental results were obtained by using a smoke tunnel and the 3-ft. wind tunnel. Effects on the lift and drag characteristics of an airfoil caused by slotting were the principal points of Mr. Hufford's paper.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Loving, Donald L., B.S. in Ae.E., Aero. Research Scientist, NACA, Langley Field.

Talbot, Curtis G., B.S.E.E., Mgr., Flight Test Center, General Electric Co. (Schenectady).

Transferred to Associate Fellow Grade

Buschmann, Rudi Paul, B.A., Dept. Mgr., Military Operations Research Div., Lockheed Aircraft Corp. (Burbank).

Carroll, Thomas D. R., Sr. Tech. Officer—Aircraft, British Overseas Airways Corp. (London).

Goddard, Frank E., Jr., B.S., Chief, Supersonic Aerodynamics Div., Jet Propulsion Lab., California Institute of Technology.

O'Malley, James A., Jr., M.S.E. in Ae.E., Proj. Aerodynamicist, Bell Aircraft Corp.

Elected to MEMBER Grade

Attias, John J., M.S., Aero. Research Engr., Member, Tech. Staff, Aero. Research, The Ramo-Wooldridge Corp.

Aurand, Henry S., Jr., M.S. in C.E., Staff Asst.—Missile Prelim. Design, Douglas Aircraft Co., Inc. (Columbus).

Baird, Bruce C., Design Engr. "A," Missile Systems Div., Lockheed Aircraft Corp. (Van Nuys).

Ball, Richard H., M.S.M.E., Proj. Engr.—Jet Engine Control Systems, General Engrg. Lab., General Electric Co. (Schenectady).

Beeching, S. R., Armaments Design Engr., Canadair Ltd.

Coursen, John W., B.S. in Ae.E., Design Engr., Grumman Aircraft Engineering Corp.

Dawson, John T., B.S., Engrg. Designer, Boeing Airplane Co. (Seattle).

Dayman, Bain, Jr., A.E., Research Engr., Jet Propulsion Lab., California Institute of Technology.

De Haven, Robert M., Asst. Dir., Aircraft Operations & Flight Test Div.; Chief, Experimental Flight Test Dept., Hughes Aircraft Co.

Demoret, Robert B., M.S., Aerodynamics Engr.—Proj. Group Leader, Missile Aerodynamics Group, Douglas Aircraft Co., Inc. (Santa Monica).

Dempsey, Bessie M., B.E.M.E., Aerodynamicist "A," Aerodynamics Div., Boeing Airplane Co. (Seattle).

Dickstein, D. H., M.S. Applied Math., Engr.—Research & Devel., AGT Div., General Electric Co. (Evendale).

Drakeley, George T., B.S., Sr. Group Engr.—Supersonic Wind Tunnel Design, Boeing Airplane Co. (Seattle).

Edgerly, Robert M., B.S.M.E., Instrumentation Engr., Grumman Aircraft Engineering Corp.

Flocken, Ambrose L., B. of Ae.E., Stress Analyst "A," Douglas Aircraft Co., Inc. (Long Beach).

Forsnas, Raymond C., B.S.M.E., Owner, Forsnas Engineering Co.

Gage, Daniel D., A.B., Chief Engr.—Electronics Installations, The Glenn L. Martin Co.

Greenblatt, Louis W., B.S.M.E., Pres., The Greenleaf Manufacturing Co.

Guerrera, Frank A., M.A., Engrg. Mathematician, Allied Research Associates, Inc.

Haase, Herman H., B.S. in C.E., Chief Research Analyst, Sales Dept., Boeing Airplane Co. (Seattle).

Irvine, James F., Jr., M.S in Ae.E., Lt., USN; Naval Aviator & Maintenance Officer, Fighter Sq. 34.

Johnson, Joseph C., Sc.M., Mgr.—Research & Devel., Titeflex, Inc.

Kaap, Lawrence E., B.S., Thermodynamics Engr., Lockheed Aircraft Corp. (Burbank).

Kenner, Lewis M., B.S.M.E., Aerodynamics Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

Kirby, Josiah J., B.S., Sect. Head, Product Engrg. Dept., Missile & Radar Div., Raytheon Manufacturing Co.

Lakomaa, Arne, M.S. in M.E., Proj. Engr., SAAB Aircraft Co. (Sweden).

Male, Donald W., M.S. in Physics, Asst. Chief, Plans Branch, Research & Devel. Div., USAF Arnold Engineering Development Center.

McGuire, Terence J., Jr., M.S. in Engrg. (Applied Mech.), Sales Engr., Wright Aero. Div., Curtiss-Wright Corp.

Morgan, Charles, M.S., Asst. Prof. of Engrg., San Diego State College.

Morris, Ray S., Engrg. Test Pilot, North American Aviation, Inc. (Los Angeles).

Mulder, Howard M., B.S.M.E., Asst. Zone Mgr., Allison Div., General Motors Corp.

Nelson, Louis D., B.S.M.E., Prelim. Design Engr., Beech Aircraft Corp.

Ostenso, Donald T., B.S.M.E., Sr. Design Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Pelstek, Arthur F., B.S.E.E., Mgr.—Contract Operations, The Leland Electric Co.

Rich, Ben R., M.S. in Engrg., Thermodynamics Engr., Lockheed Aircraft Corp. (Burbank).

Richardson, Laurence B., Jr., M.S. in Ae.E., Lt. Comdr., USN; Proj. Pilot, Carrier Branch, Flight Test Div., NATC, Patuxent River.

Roemer, Robert L., B.S.M.E., Design Engr., Grumman Aircraft Engineering Corp.

Romander, Ake, Civilingenjor, Mgr. of Production, Scandinavian Airlines System (Sweden).

Shapiro, H. L., B.S.M.E., Engr.—Systems, Analysis & Aerodynamics, Sperry Gyroscope Co.

Shields, G. R., B.S.M.E., Asst. Mgr., Military Requirements Dept., Allison Div., General Motors Corp.

Sisson, T. U., B.S., Capt., USN (Ret.); Military Adviser, Fairchild Aircraft Div., Fairchild Engine and Airplane Corp.

Smith, Ted R., V-P & Dir., Engrg. Research & Devel. Div., Aeronautical Design and Engineering Co.

Somerson, Herbert G., B.S., Chief of Dynamics, Dynamics Dept., Engrg. Div., Piasecki Helicopter Corp.

Vaglio-Laurin, Roberto, Ph.D. Applied Mech., Research Group Leader, Polytechnic Institute of Brooklyn.

Valentine, Clare I., B.S.M.E., Asst. Chief, Cargo & Trainer Aircraft Div., WADC, ARDC, Wright-Patterson AFB.

Wyatt, DeMarquis D., B.S. in M.E., Asst. Chief, Supersonic Propulsion Div., NACA (Cleveland).

Transferred to MEMBER Grade

Darling, Ralph E., M.S. in Ae.E., Aerodynamics Group Engr. (Supervisory), Convair, Ft. Worth, A Div. of General Dynamics Corp.

Filler, Lewis, M. of Ae.E., Instructor, Aero. Engrg., College of Engrg., New York Univ.

Frazer, Alson C., M.Sc., Aerodynamics Engr.; Lead Engr.—Inlet Design, Northrop Aircraft Corp.

Herfurth, John J., M.S. in Ae.E., Aerodynamicist, Aerodynamics Sect., Design Group, Douglas Aircraft Co., Inc. (El Segundo).

Oates, Clifford, Jr., B.A.E., Thermodynamics Engr., Airconditioning Group, Lockheed Aircraft Corp. (Burbank).

Richardson, Donald W., B. of Ae.E., Sr. Aerodynamics Engr., Propeller Div., Curtiss-Wright Corp.

Sherborne, Henry H., Lt. Col., USAF; Arnold Engineering Development Center,

Stanton, John R., B.S. in Ae.E., Sales Engr., Walter Kidde & Co., Inc.

Surbeck, Richard U., B.S. in Ae.E., V-P-Aviation Sales & Engrg., Aviquipo, Inc.

Elected to Associate Member Grade

Anderson, James D., B.S.M.E., Chief Engr., Klincher Locknut Corp.

Bobzin, Lyle D., Capt.-Pilot, Trans World Airlines, Inc. (Chicago).

Fagalde, Fernando M., B.S. in M.E., Col., Chief of Purchasing Div. (Wash., D.C.), Chilean Air Force Commission.

Systems Development and The Ramo-Wooldridge Corporation

The Ramo-Wooldridge Corporation (except for the specialized activities of our subsidiary, Pacific Semiconductors, Incorporated) is engaged primarily in developing—and will soon start to manufacture—systems rather than components. For military customers our weapons systems responsibilities are in the fields of guided missiles, fire control, communications, and computers. Our non-military systems activities are in the general area of automation and data-processing.

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Therefore, competent systems development requires that a company contain an unusually large proportion of mature, experienced scientists and engineers who have a wide range of technical understanding and an unusual breadth of judgment. Further, all aspects of company operations must be designed so as to maximize the effectiveness of these key men, not only in the conduct of development work but in the choice of projects as well.

At Ramo-Wooldridge we are engaged in building such a company. Today our staff of professional scientists and engineers comprises 40% of the entire organization. Of these men, 40% possess Ph.D. degrees and another 30% possess M.S. degrees. The average experience of this group, past the B.S. degree, is more than eleven years.

We believe the continuing rapid growth of our professional staff is due, in part, to the desire of scientists and engineers to associate with a large group of their contemporaries possessing a wide variety of specialties and backgrounds. It is also an indication that such professional men feel that the Ramo-Wooldridge approach to systems development is an appropriate one.

We plan to continue to maintain the environmental and organizational conditions that scientists and engineers find conducive to effective systems development. It is on these factors that we base our expectation of considerable further company growth.

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Pacharzina, Carl A., Jr., Major, USAF; Asst. Executive to the DCS/D, Hq. USAF.

Rose, William B., B.S., Mgr., Devel. Dept., Westvaco Chlor-Alkali Div., Food Machinery & Chemical Corp. (N.Y.).

Waldo, Richard K., A.B., Market Research Mgr., Commercial Sales Dept., Convair, San Diego, A Div. of General Dynamics Corp.

Elected to Technical Member Grade

Alles, Thomas W., B.S.A.E., Aerodynamicist, McDonnell Aircraft Corp.

Austin, Gerard C., B.M.E., Research Engr.—Vibration & Flutter Analysis, Grumman Aircraft Engineering Corp.

Bonomo, Philip J., S.M., 1st Lt., USAF; Research & Devel. Officer (Electronics Engr.), Wright-Patterson AFB.

Cruthirds, James E., B.S. in Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Long Beach).

Glatfelter, Edward W., B.S., Design Analyst, Sikorsky Aircraft, Div. of United Aircraft Corp.

Hatcher, Winnie M., M.S. in Math., Advanced Mathematician, North American Aviation, Inc. (Columbus).

Hochman, Samuel, B. of Ae.E., Flight Research Engr., Sikorsky Aircraft, Div. of United Aircraft Corp.

King, John H., B.S., Tech. Engr., Group Leader of Air Design Group, Engine Design Sect., Aircraft Nuclear Propulsion Dept., General Electric Co. (Evendale).

Latz, Robert N., M.S., Assoc. Engr., Boeing Airplane Co. (Seattle).

Petty, Raymond A., B.S. in Ae.E., Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Segal, Marshall M., B.S. in M.E., Research Engr., Worthington Corp.

Sprunk, William, Jr., B.S.E.E., Lt. (j.g.), USN; Electronics Officer, Airborne Early Warning Sq. Three.

Warynick, Edward W., A.M. in Ae.E., Group Supvr.—Flight Test Analysis & Operations, Temco Aircraft Corp.

Transferred to Technical Member Grade

Allen, John E., B.S. in Ae.E., Jr. Test Engr., Pratt & Whitney Aircraft, Div. of United Aircraft Corp.

Anderson, Thomas L., B.A.E., Flight Test Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Barnes, Kenneth H., B.S. in Ae.E.

Bollard, Richard T. H., Ph.D. (Ae.E.), Consultant, James Aviation, Ltd. (New Zealand).

Bonisch, Frank H., Design Engr., Piper Aircraft Corp.

Coffey, Glenn A., Jr., Jr. Engr.—Aerodynamics, North American Aviation, Inc. (Los Angeles).

Cohen, Edward C., B.A.E., Structures Engr., Grumman Aircraft Engineering Corp.

Covey, Claude, Mathematician, Stress Group, Douglas Aircraft Co., Inc. (Long Beach).

Diamant, Benjamin, B. of Ae.E., Lt., USAF; Aerodynamic Proj. Engr., Transonic Unit, Wind Tunnel Branch, WADC, Wright-Patterson AFB.

Esenwein, George F., Jr., B.S. in Ae.E.

Gatehouse, William A., Jr., Propulsion Engr., Grumman Aircraft Engineering Corp.

Geller, Edward W., M.S. in AeE., Asst. Prof., Univ. of Alabama.

Glenn, Hayden F., B.S., Assoc. Aircraft Engr., Lockheed Aircraft Corp. (Marietta).

Groves, John M., Draftsman "A," Northrop Aircraft Co.

Johnson, Richard H., B.M.E., 2nd Lt., USAF; Student Pilot, Bartow AFB.

Kolar, W., B.S. in Ae.E., Sr. Tech. Rep., Northrop Aircraft, Inc.

Kolenkiewicz, Ronald, B.S.

LaPorte, Alfred H., Assoc. Engr. (Struct.), The Glenn L. Martin Co.

Leaf, William D., B.S. in Ae.E., Graduate Asst., Case Institute of Technology.

Lemnios, Andrew Z., S.M., Research Engr., United Aircraft Corp.

Locke, John W., B.S. in Ae.E., Engr. "B," Flight Test Data, McDonnell Aircraft Corp.

Lutz, Gerald E., B.S. in Ae.E., Assoc. Engr., The Glenn L. Martin Co.

Maggos, George P., Jr. Stress Engr., The Glenn L. Martin Co.

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McCurley, J., B.S. in Ae.E., Equipment Engr., Chance Vought Aircraft, Inc.

Miller, Kenneth W., B.S. in Aero., 2nd Lt., USAF; Aero. Engr., Hq. Air Terminal Intelligence Center, Wright-Patterson AFB.

Montague, Joe A., Chief Inspector, E. B. Wiggins Oil Tool Co., Inc.

Nyenhuis, Roger J., B.S. Engrg.

Nylund, Thomas C., B.S., Aerodynamicist, Grumman Aircraft Engineering Corp.

Parker, Morton J., Designer, Northrop Aircraft, Inc.

Parli, Clifford L.

Powell, Robert D., Jr., B.M.E., Aero. Research Scientist, NACA, Langley AFB.

Pratt, Calvin Lee, Jr., B. of Ae.E., Jr. Engr., Chance Vought Aircraft, Inc.

Regan, Joseph F., M.S.M.E., Capt., USAF; A.F. Devel. Field Rep., Research & Devel. Command.

Shulman, Arnold L., B.S., Proj. Engr., Power Plant Branch, Air Force Flight Test Center (Edwards).

Sproull, William C., Jr., B.S.A.E., Graduate Student, Univ. of Michigan.

Varisco, Angelo A., Aircraft Designer, Grumman Aircraft Engineering Corp.

Webb, Steven L., B.S., 2nd Lt., USAF; Aero. Repair Officer & Aircraft Maintenance Engr., 483rd Field Maintenance Sq.

Wennhold, William F., Jr. Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Zukoski, Edward E., Ph.D., Research Engr., Jet Propulsion Lab., California Institute of Technology.

Southwestern Student Competition

(*Continued from page 19*)

the value of timing and salesmanship to the engineer. He stated that the right idea at the wrong time usually dies of apathy. In addition, an engineer must sell himself before he can successfully sell his ideas.

A barbecue dinner for students and faculty was held Thursday evening on the lawn adjoining the Fort Worth Art Center. Following the barbecue, a Specialist Meeting was held in the Art Center with R. T. Jones, Aeronautical Research Scientist, NACA, as speaker. His title was "Possibilities of Efficient High-Speed Transport Airplanes." He presented a most interesting and entertaining discussion of the more important aerodynamic considerations involved in the design of high-speed transport airplanes.

On Saturday, the students and faculty participating in the competition, as well as more than 40 other students and IAS members, were taken on a tour of the plant facilities of Bell, Chance Vought, Convair, and Temco. Luncheon was provided by Chance Vought.

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Saturday evening the Awards Night Dinner was held in the Continental Terrace Room of the Hilton Hotel. It was attended by some 160 members of the Texas Section and their guests, in addition to the students and faculty. After dinner, Chairman H. F. Marx welcomed the gathering and introduced the honored guests, including G. H. Linnaberry, Chief Development Engineer, Bell Aircraft, Texas Division; F. W. Davis, Chief Engineer, Convair, Fort Worth; Col. C. Savage, USAF, AFPR, Fort Worth; A. C. Esenwein, Vice-President, Convair; Harvey Gaylord, Vice-President, Bell Aircraft; E. W. Robischon, Manager, Western Region, IAS; C. J. McCarthy, Chairman of the Board, Chance Vought; I. N. Palley, Vice-President, Temco; Capt. C. M. Jett, USN, BAR, Dallas; and R. C. Blaylock, Chief Engineer, Chance Vought.

Following the introduction, Mr. Marx gave a brief résumé of the competition, mentioning some of the highlights. He then called upon J. H. Boucher, Vice-Chairman of the Texas Section, to introduce the principal speaker of the evening. Mr. Boucher outlined a remarkable career before introducing its owner, Rear Adm. Luis de Florez.

Admiral de Florez had as the title of his speech "An Old Hand Takes a New Look." He looked back 700,000 years and observed that man had learned a lot in that time but still has nearly the same size brain. He also observed that technological development was proceeding at an ever-increasing pace, especially in the past century or two. This led him to the conclusion that engineers and scientists would do well to pay more and more attention to the relationship between machines and their human operators, lest the machines become useless because of the inability of men to cope with them.

The final and climaxing event of the competition was the presentation of awards to the winning students. The Undergraduate Division winners were: *First Prize*, O. Larry Gillette, University of Utah, "The Effect of High Temperatures on Localized Stresses in Alloy Steel"; *Second Prize*, Paul A. Lord, University of Colorado, "Rocket Nozzle Research with High-Pressure Air"; *Third Prize* (*tie*), Charles J. Stalmach, University of Texas, "Supersonic Diffuser Designs for Supersonic Wind Tunnels," and Ang Dinh Dang, University of Kansas, "Compressible Turbulent Boundary Layer Displacement Thickness with Heat Transfer."

The winners in the Graduate Division were: *First Prize*, Vernon A. Lee, University of Texas, "Interference Effects from Total Pressure Probe Rakes in Supersonic Flow"; *Second Prize*, J. M. Boulware, Georgia Institute of Technology, "The Effect of Large External Stores on the Low-Speed Pitching and Yawing Characteristics of a 60° Delta Wing." No third prize was given.

The Third Southwestern Student Competition was closed with a resolution of appreciation to the Texas Section, the IAS, and the sponsoring companies. The resolution was offered by Glenn Murphy, of Iowa State College, on behalf of the students and faculty members.

A. T. CLEMEN
Publicity Chairman
Texas Section

St. Louis Section's Student Competition

(*Continued from page 20*)

versity in 1917, he received a B.S. in Mechanical Engineering from Washington University in 1920. From 1921 to 1934, Mr. Tucker was an Instructor, Assistant Professor, and Associate Professor in the Mechanical Engineering Department at Washington University. For the next 3 years, he was Secretary to the Mayor of St. Louis and then for 5 years was Commissioner of Smoke Regulation, in which job he achieved national recognition. From 1942 to 1953, Mr. Tucker was Professor and Head of the Mechanical Engineering Department at Washington University. He was elected Mayor in 1953.

Speaking on "The Engineer and His Civic Duty," Mayor Tucker declared professional engineers should exercise their right to vote, take an active part in public affairs, and make their opinions known publicly.

"The engineer has a unique obligation to be a good citizen," said the Mayor, "for he played a major role in bringing problems to the government at all levels. He created the automobile and the thousands of machines and material things that make life more complex today.

"On the basis of more than 30 years of intimate association with colleagues in the engineering profession, coupled with 20 years of direct contact with civic affairs, I have arrived at a rather unflattering conclusion with respect to engineers and their use of the franchise."

Engineers are inclined to vote every 4 years in an election that has some glamour attached to it, he said, but little is heard from them at the minor elections.

"Yet by temperament, training, and experience," he continued, "an engineer is qualified to make the very best use of the franchise.

"He is an objective person, given to cautious and close analysis of all sides of a question before making a decision. He is judicious and studious. He is not moved by emotional appeals or the razzle-dazzle of insincere propaganda. But he lacks the dynamic conviction of his own importance and value as a citizen."

Another obstacle to be overcome, Mayor Tucker said, is the engineer's unwillingness or inability to speak up on public issues.

"We must cast off this mantle of reticence," he said. "We must become more active in civic groups of all kinds. Being more active means being more vocal. Engineers not only must be clear and logical—they also must become persuasive.

"We have a wealth of talent and ability to be made available to the solution of civic problems. But we must cease hiding it under a bushel. We must learn how to *sell* as well as *build*."

After his talk, the Mayor presented the awards to the winners, whom Professor Kippenhan introduced.

A. H. MADRICK
Chairman, Publicity Committee
L. A. SMITH
Secretary, St. Louis Section

West Coast Conference

(*Continued from page 21*)

Producing Efficient Wide-Angle Diffusers," by David L. Cochran, Stanford University.

North American Aviation was host at luncheon on Thursday in the IAS Building. In the afternoon, the students toured Douglas Aircraft plants at Long Beach and Santa Monica. The following day was spent in touring Lockheed, Marquardt, and North American plants.

On Friday evening, the group gathered at the IAS Building for the Awards Banquet. The awards were presented by the three judges—George N. Mangurian, Chief of Structures, Northrop Aircraft, Inc.; Carl Babberger, Chief of Research, Aircraft Division, Hughes Tool Company; and Robert R. Templeton, Group Leader, Power Plant Test, North American Aviation, Inc. Each participant was given an engraved gold pencil by Mr. Mangurian.

Mr. Babberger then presented the undergraduate awards. Leroy L. Pressley, of Oregon State College, won first prize of $100. Victor L. Peterson, also of Oregon State, took second prize of $50. Richard M. Knox, of Stanford University, received honorable mention.

Mr. Templeton presented the graduate awards. David L. Cochran, of Stanford, captured the $100 first prize. John Marion, of UCLA, received $50

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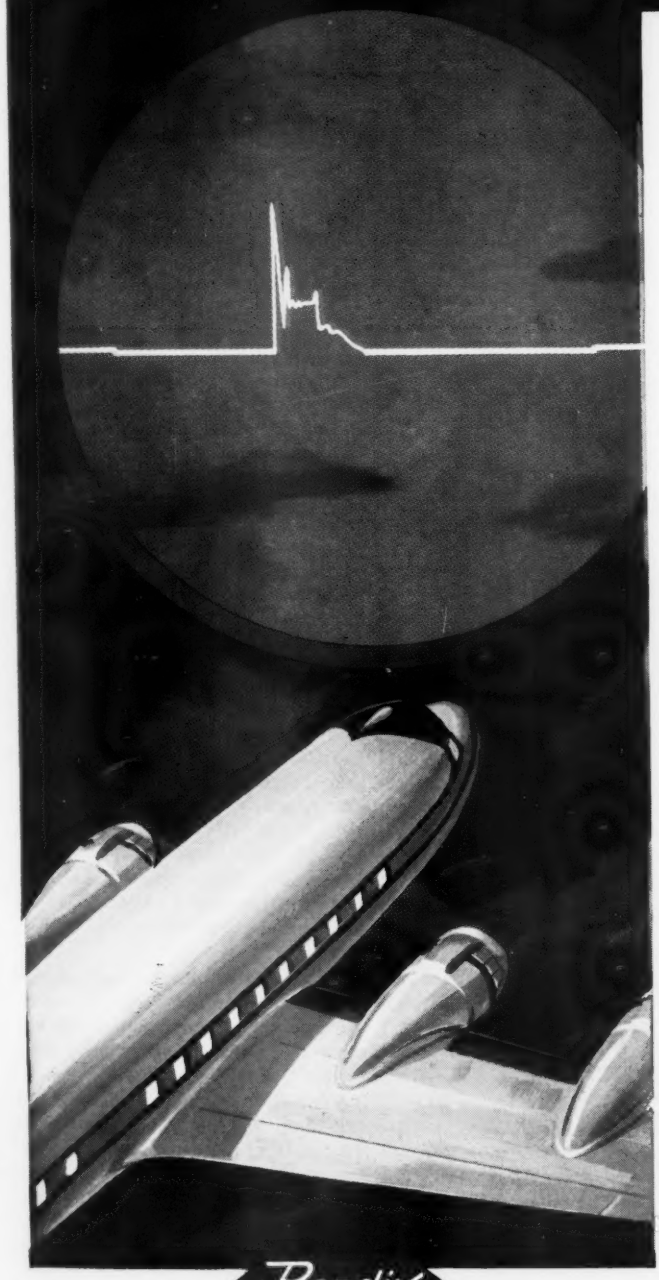

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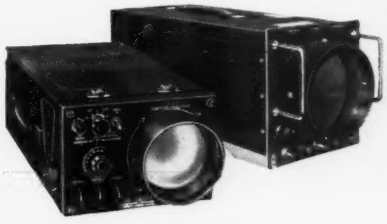

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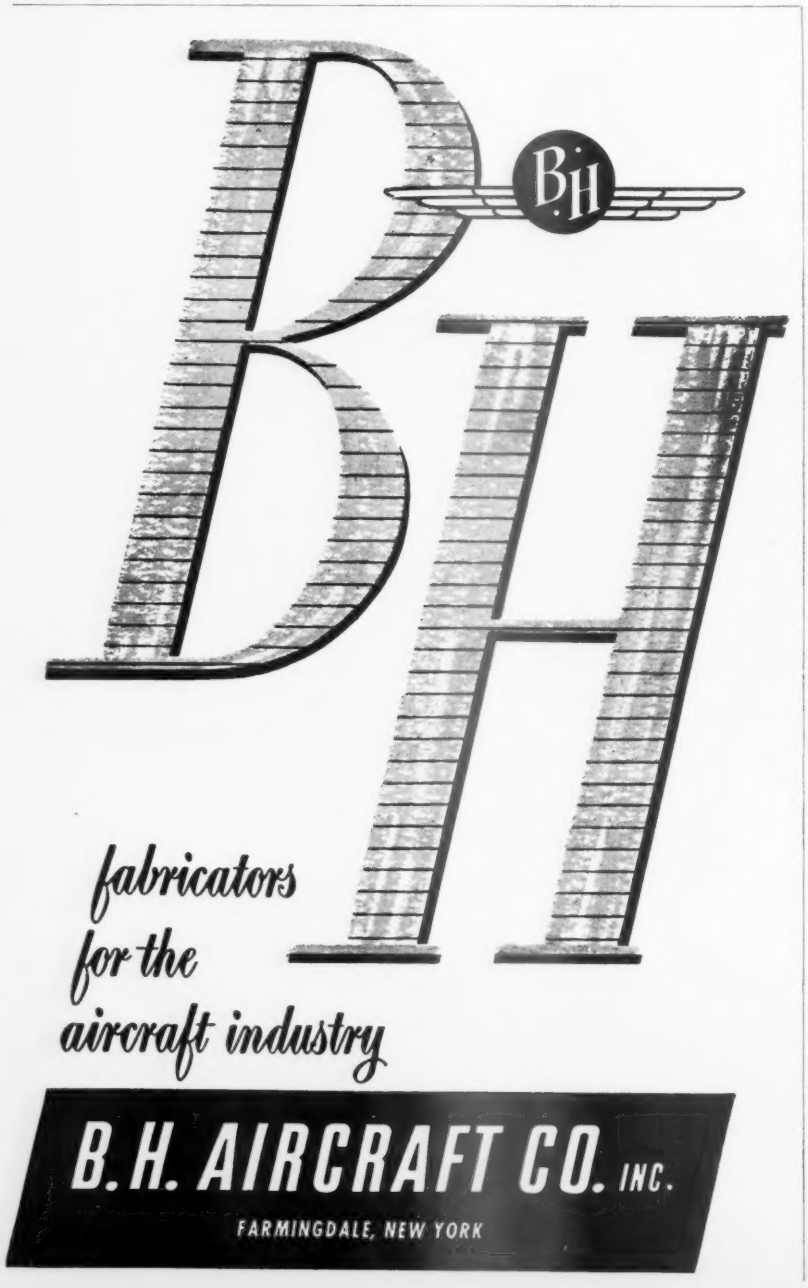
for second place. Paintings of the Northrop F-89 Scorpion were given to Mr. Pressley and Mr. Cochran as additional prizes.

Mr. Mellinger introduced the guest speaker, Ernest G. Stout, FIAS, Staff Engineer, Convair Division. Speaking on "Your Tomorrow," Mr. Stout gave the students an insight into what industry expects of new engineers and how the young engineer can best prepare for entry into the profession. He emphasized that to build a career, the young engineer must be always attentive, always learning. Above all, he must be patient and willing to wait if his dreams are not realized immediately. Mr. Stout went on to predict that within the next 20 years the United States would have a strong aerial merchant fleet, nuclear-powered aircraft, and a man-made satellite.

He concluded by showing films of current Convair airplanes, including the turboprop Tradewind, a large cargo seaplane; the Pogo, first successful vertical-take-off fighter; and the Sea Dart, the only water-based jet fighter in existence.

FRANK E. WASHBURN
Student Activities Committee
Los Angeles Section



AHS Annual Forum

(*Continued from page 22*)

application or operation of rotary-wing aircraft."

Speaking at the dinner, Mr. Lee outlined steps to make helicopter service attractive to those who make intercity trips of 150 to 700 miles. He estimated this travel market at 133,000,000 passengers a year.

"In addition to safety and downtown heliports," he said, "another essential for real mass use of helicopters in short-haul transport service is the ability to fly on instruments.

"At present, no helicopter operator is certificated for instrument flight. Thus the schedule dependability which has contributed to growth of air-line traffic cannot be offered as an attraction to helicopter patrons."

Instrumentation poses a difficult problem, he said, because helicopters require as much as 80 control movements per minute, compared to three or four for fixed-wing aircraft.

"Much breath has been wasted," the Administrator continued, "arguing whether heliports should be designed to match the helicopters or helicopters designed for the heliports. There is a clear path of action open to all interested parties. The makers of rotorcraft must strive for a vehicle which can safely take off in a near-vertical direction, and which keeps noise to a minimum. Those are the needs of military and civil users, whatever the ultimate nature of the heliport. It should be clear to municipal planners that downtown land will get scarcer and scarcer and that obtaining at least an option now on ample space for a heliport could hardly leave them with a white elephant on their hands."

Eleven helicopter types have been certificated by the CAA, Mr. Lee said, and several others are nearing certification.

Mr. Gewirtz told the audience that the first problem to be solved is the development and production of an economical vehicle of transportation in the rotary-wing field.

"You must convince the aircraft manufacturers that there is a tremendous waiting market for helicopter operations," he said.

"Ultimately, the right kind of Civil Air Regulations must be written for rotary-wing aircraft. Now is the time to anticipate the new and different traffic control problems which will be created by high-density rotary-wing operations. More important than anything else is the necessity to condition communities so that they will accept the concept of increased helicopter operations."

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

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Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada; excepted are certain reference books and IAS publications which are available for purchase. Members of The Paul Kollsman Lending Library who are not members of the Institute may borrow books and, in special cases, other research material. Members of the IAS may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 8½- by 11-in. print and $0.40 to members and Corporate Members ($0.50 to nonmembers) for each 11½- by 14-in. print, plus postage. A minimum charge of $1.00 is made to nonmembers of the IAS. Reference citations in the Aeronautical Reviews Section give the total number of pages for report and booklet materials; only the beginning page is given for periodical articles.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $15 to $20 per 1,000 words, depending on the language.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

Abbreviations for Titles of Periodicals and Reports

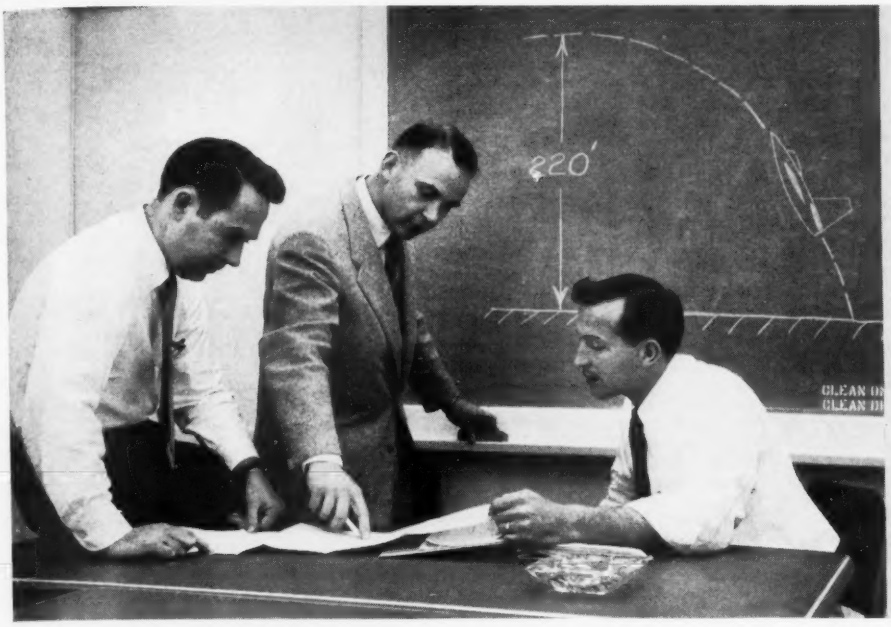
Titles of periodicals and reports cited in the Aeronautical Reviews Section are abbreviated in order to conserve space and to expedite the flow of materials. Selection of titles in this list of abbreviations is based on materials received during the past year. Reference citations are listed in the briefest form, with only the first page given for periodicals and the total number of pages for reports and other types of publications.

Publications reviewed are filed permanently in the IAS Library. Requests for loans of materials should be directed to the Librarian, IAS Library, 2 E. 64 St., New York 21, N. Y.

A&M Coll. Tex. Eng. Exp. Sta. Res. Rep. Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Research Report
Acta Polytechnica (Stockholm)
ADA Info. Bul.; Res. Rep. The Aluminium Development Association, Information Bulletin; Research Reports (London)
Aero Dig. Aero Digest
Aero. Argentine Commun. & Inform. Aeronautica Argentine, Communicación e Información
Aero. Eng. Rev. Aeronautical Engineering Review
Aero. Inst. Tech. Hochschule, Braunschweig, Bericht. Aerodynamisches Institut der Technischen Hochschule, Braunschweig, Bericht
Aero. Quart. The Aeronautical Quarterly
Aero. Res. TN; Bul. Aero Research Technical Notes; Bulletin
Aero. Versuchsanstalt, Luftfahrtforschung, Bericht. Aerodynamischer Versuchsanstalt, Göttingen, Luftfahrtforschung, Bericht
Aeronautics
The Aeroplane
L'Aerotecnica (Rome)
Aerovox Res. Worker. Aerovox Research Worker
AHS Papers. American Helicopter Society, Papers
AIAA Papers. Aircraft Industries Association of America, Papers
AIEE Papers. American Institute of Electrical Engineers, Papers
Air Facts
Air Force
Air Line Pilot
Air Pictorial
Air Rev. Air Revue (Brussels)
Air Transp. Air Transportation
Air U. Quart. Rev. Air University Quarterly Review
Airborne Inst. Lab. Proj. Rep. Airborne Instruments Laboratory, Project Report
Aircraft (Australia)
Aircraft (Canada)
Aircraft Eng. Aircraft Engineering
Aircraft Heating Dig. Aircraft Heating Digest
Aircraft Prod. Aircraft Production
Airport Operators Council, Papers
Airports & Air Transp. Airports & Air Transportation
Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review
ALPA Papers. Air Line Pilots Association, Papers
Am. Av. American Aviation
Am. Engr. American Engineer
Am. Helicopter. American Helicopter
Am. J. of Phys. American Journal of Physics
An. d. Phys. Annalen der Physik (Germany)
An. Fis. Quim. Anales de Fisica y Quimica (Madrid)
An. Soc. Cientifica. Anales Sociedad Científica (Argentina)
Anal. Chem. Analytical Chemistry
Antiaircraft J. Antiaircraft Journal
Appl. Hydraulics. Applied Hydraulics
Appl. Mech. Rev. Applied Mechanics Reviews
Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A (Mechanics, Heat, Chemical Engineering, Mathematical Methods)
Appl. Sci. Res., Sect. B. Applied Scientific Research, Section B (Electrophysics, Acoustics, Optics, Mathematical Methods)
Arch. Budowy Maszyn. Archiwum Budowy Maszyn, Polska Akademia Nauk, Komitet Budowy Maszyn (Warsaw)
Arch. für Eisenhüttenwesen. Archiv für Eisenhüttenwesen (Germany)
Arch. für Tech. Messen (Munich)
Arch. Mech. Stosowanej. Archiwum Mechaniki Stosowanej, Zakład Mechaniki Ośrodków Ciagłych Polskiej Akademii Nauk (Warsaw)
Argonne Natl. Lab. Rep. Argonne National Laboratory, Reports
ASCE Air Transp. Div. Papers; Preprints. American Society of Civil Engineers, Air Transport Division, Papers; Preprints
ASME Preprints; Papers. American Society of Mechanical Engineers, Preprints; Papers
ASTM Bul. American Society for Testing Materials, Bulletin
Astronautica Acta
Astronautics (Journal of the American Astronautical Society)
ATA Papers. Air Transport Association (of America), Papers
Audio
Australia, Aero. Res. Consultative Comm. Rep. Australia, Department of Supply, Aeronautical Research Consultative Committee, Reports
Australia, ARL EN; IN; Rep.; S&M Monogr.; S&M TM; Notes. Australia, Department of Supply, Aeronautical Research Laboratories, Engines Note; Instruments Note; Reports; Structures and Materials Monographs; Structures and Materials Technical Memorandum; other Notes
Australia, CSID Aero. Res. Rep. Australia, Council for Scientific and Industrial Research, Aeronautical Research Reports
Australian J. of Appl. Sci. Australian Journal of Applied Science
Australian J. Phys. Australian Journal of Physics [formerly Australian Journal of Scientific Research, Series A (Physical Sciences)]
Auto. Ind. Automotive Industries
Auto-Technik (Berlin)
Av. Age. Aviation Age
Av. Week. Aviation Week
Avia Vliegwereld (Netherlands)
Aviaçao (Rio de Janeiro)

Bearing Engr. Bearing Engineer
Bee Hive
Bell Aircraft Rep. Bell Aircraft Corporation, Reports
Bell System Tech. J. Bell System Technical Journal
Bendix Av. Eng. Rep. Bendix Aviation Corporation, Engineering Reports
Boeing Mag. Boeing Magazine
Bristol Quart. The Bristol Quarterly
Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin
Brit. J. Appl. Phys. British Journal of Applied Physics
Brit. Welding J. British Welding Journal
Brown-Boveri Rev. Brown-Boveri Review
Brown U. Div. Eng., USAF TR. Brown University, Division of Engineering, United States Air Force, Technical Reports
Bul. Acad. Polonaise Sci. Bulletin de l'Academie Polonaise des Sciences (Warsaw)
Bul. AMS. Bulletin of the American Meteorological Society
Bul. Ass. Suisse Élec. Bulletin, Association Suisse des Électriciens
Bul. Serv. Tech. Aéro. Bulletin du Service Technique de l'Aéronautique (Brussels)
Bul. Soc. Française Élec. Bulletin, Société Française des Électriciens
Bus. Flying. Business Flying

C. R. Acad. Sci., Paris. Compte Rendu de l'Académie des Sciences, Paris
CAI Log. Canadian Aeronautical Institute, Log (Superseded by **Can. Aero. J.**)
Can. Aero. J. Canadian Aeronautical Journal
Can. Airline Pilot. Canadian Airline Pilot
Can. Av. Canadian Aviation
Can. J. Phys. Canadian Journal of Physics
Can. J. Tech. Canadian Journal of Technology
Canada, CARDE Misc. Rep. Canada, Canadian Armament Research and Development Establishment, Miscellaneous Reports
Canada, Dept. Mines & Tech. Surveys Rep. Canada, Department of Mines and Technical Surveys, Reports
Canada, DRML Rep. Canada, Defence Research Medical Laboratories, Reports
Canada, NAE HSAL Rep. Canada, National Aeronautical Establishment, High Speed Aerodynamics Laboratory, Reports
Canada, NAE LR; Note; Quart. Bul.; Rep. Canada, National Aeronautical Establishment, Laboratory Report; Note; Quarterly Bulletin; Reports
Canada, NRC Div. Mech. Eng. Rep. Canada, National Research Council, Division of Mechanical Engineering, Reports
Canada, RCAF Rockcliffe, Rep. Canada, Royal Canadian Air Force, Rockcliffe, Reports



N. T. Avant, aerodynamicist (left), R. R. Heppe, Aerodynamic Department head (center), and C. F. Branson, aerodynamicist, discuss wind tunnel tests to determine transition height of a supersonic superiority fighter.

Hovering to High Speed Flight:

Lockheed Aerodynamics Projects Offer Advanced Problems

Additional information on these problems and data on Lockheed's Aerodynamics Division is available to interested engineers. Address inquiries to R. R. Heppe.

Aerodynamics Engineers at Lockheed are working on advanced problems that cover virtually every phase of aircraft. The full scope of their work can be seen in the wide range of aerodynamics problems encountered in Lockheed's diversified development program.

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1. Determine means of controlling a supersonic vertical rising aircraft through the transition flight stages from horizontal to vertical flight.
2. Determine the dynamic response of supersonic aircraft in high rate rolls by application of five degrees of freedom analysis procedures.
3. Study optimum operating descent procedures to minimize costs on a new turboprop commercial aircraft.
4. Conduct and analyze wind tunnel research on new and radically different external radomes to be carried at high speed by early warning aircraft.
5. Perform generalized aeroelastic analysis combining structural and aerodynamic knowledge to determine optimum lateral control devices for use on very high speed, low load factor aircraft.

These—and many other—significant problems have created new positions for experienced Aerodynamics Engineers and Aerodynamicists in Lockheed's expanding program of diversified development.

You are invited to write E. W. Des Lauriers, Dept. A-5-7, for a brochure describing life and work at Lockheed in the San Fernando Valley and an application form.

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CEC Recordings
Cen. Sviluppo Transp. Aerei. Centro per lo Sviluppo dei Transporti Aerei (Rome)
Chartered Mech. Engr. The Chartered Mechanical Engineer (London)
Chrysler Eng. Div. Rep. Chrysler Corporation, Engineering Division, Reports
Ciampino (Interairport) (Rome)
CIT Hydrodynamics Lab. Rep. California Insitute of Technology, Hydrodynamics Laboratory, Reports
CIT Jet Propulsion Lab. Prog. Rep. California Institute of Technology, Jet Propulsion Laboratory, Progress Reports
CIT Mech. Eng. Lab. Rep. California Institute of Technology, Mechanical Engineering Laboratory, Reports
CIT Papers. California Institute of Technology, Papers
Coll. of Aeronautics, Cranfield, Rep. College of Aeronautics, Cranfield, England, Reports
Collins Signal
Commun. on Pure & Appl. Math. Communications on Pure and Applied Mathematics
Cook Res. Labs. Papers. Cook Research Laboratories, Papers
Cornell Aero. Lab. FRM; Rep.; Transl. Cornell Aeronautical Laboratory, Inc., Flight Research Memorandum; Reports; Translations
Cornell-Guggenheim Av. Safety Cen. Papers; Rep. Cornell-Guggenheim Aviation Safety Center, Papers; Reports
Cornell U. Med. Coll. Crash Injury Res. Papers. Cornell University Medical College, Crash Injury Research Papers
Corrosion
Curtiss-Wright Corp., Wright Aero. Div., Rep. Curtiss-Wright Corporation, Wright Aeronautical Division, Reports

de Havilland Gazette
Dickinson Law Rev. Dickinson Law Review
Dokl. Akad. Nauk. Doklady Akademiia Nauk (Leningrad)
Douglas Rep. Douglas Aircraft Company, Inc., Reports
Douglas Serv. Douglas Service

Elec. Commun. Electrical Communication
Elec. Eng. Electrical Engineering
Elec. Mfg. Electrical Manufacturing
Electronic Eng. Electronic Engineering
Electronics
Electronics Forum. See **Proc. Inst. Electronics**
L'Elettrotecnica (Italy)
Eng. J. Engineering Journal
The Engr. The Engineer
Engr. Dig. Engineer's Digest
Ericsson Rev. Ericsson Review
Escher Wyss News
Esso Air World
Esso Standard Oil Co. Rep. Esso Standard Oil Company, Reports
ETH Inst. für Aerodynamik (Zurich), Mitteilungen. Eidgenössische Technische Hochschule, Institut für Aerodynamik (Zurich), Mitteilungen

Fasteners
Flight
Flight Control (Bendix)
Flight Mag. Flight Magazine
Flight Safety Foundation Mech. Bul. Flight Safety Foundation, Inc., Mechanics Bulletin
Flight Safety Foundation, Papers
Flying
Flying Safety (USAF). Flying Safety (United States Air Force)
Focke-Wulf Flugzeugbau GmbH, Bremen/Werkstoff-Versuchsabteilung, Tech. Berichte. Focke-Wulf Flugzeugbau, Gesellschaft mit beschrankter Haftung, Bremen/Werkstoff-Versuchsabteilung, Technische Berichte (Germany)
Foote Prints
France, Min. de l'Air BST; NT; PST. France, Ministère de l'Air, Bulletin des Services Techniques; Notes Techniques; Publications Scientifiques et Techniques
France, Min. des Travaux Publics, Transp. et Tourisme, Bul. Liaison et Doc. du Sec. Gén. Av. Civ. et Com. France, Ministère des Travaux Publics, des Transports et du Tourisme, Bulletin de Liaison et de Documentation du Secrétariat Général à l'Aviation Civile et Commerciale
France, ONERA Pubs. France, Office National d'Études et de Recherches Aéronautiques, Publications
Franklin Inst. Labs. TR. Franklin Institute Laboratories for Research and Development, Technical Reports
French Acad. Devel. Aero. Res. & Aero. Tech. Serv. Rep. French Academy for the Development of Aeronautical Research and Aeronautical Technical Service, Reports
French Comm. Devel. Aero. Res. TN. French Committee for the Development of Aeronautical Research, Technical Notes
The Frontier
Fulmer Res. Inst. Rep. Fulmer Research Institute Limited, Reports

GALCIT Memo. Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, Calif., Memorandums
Garbell Res. Foundation, Aero. Ser. Garbell Research Foundation, Aeronautical Series
G-E Rev. General Electric Review
Gen. Radio Exp. General Radio Experimenter
Ges. d. Wiss. Göttingen, Nach, a. d. Math. Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse, Nachrichten aus der Mathematik (Germany)
GFW Forschungsreihe, Bericht. Gesellschaft für Weltraumforschung, Forschungsreihe, Bericht (Stuttgart, Germany)
GM Eng. J. General Motors Engineering Journal
Goodyear Aircraft Corp. Rep. Goodyear Aircraft Corporation, Reports
Gt. Brit., AAEE Rep. Great Britain, Aeroplane and Armament Experimental Establishment, Boscombe Down, Reports
Gt. Brit., AERE Rep. Great Britain, Atomic Energy Research Establishment, Reports
Gt. Brit., ARC CP. Great Britain, Aeronautical Research Council, Current Papers
Gt. Brit., ARC R&M. Great Britain, Aeronautical Research Council, Reports & Memoranda
Gt. Brit., DSIR FPR Bul. Great Britain, Department of Scientific & Industrial Research, Forest Products Research Bulletin
Gt. Brit., Meteorological Off. Prof. Notes & Reps. Great Britain, Meteorological Office, Professional Notes and Reports
Gt. Brit., Min. Transp. & Civil Av. Rep. Great Britain, Ministry of Transport and Civil Aviation, Reports
Gt. Brit., MOS GDC TIB Rep. & Transl. Great Britain, Ministry of Supply, Government Defense Council, Technical Information Bureau, Reports and Translations
Gt. Brit., MOS TIB S&T Memo. Great Britain, Ministry of Supply, Technical Information Bureau, Scientific and Technical Memorandum
Gt. Brit., NGTE Rep. Great Britain, National Gas Turbine Establishment, Reports
Gt. Brit., NPL Aerodynamics Div. Rep. Great Britain, National Physical Laboratory, Aerodynamics Division, Reports
Gt. Brit. RAE FPRC Rep. Great Britain, Royal Aircraft Establishment, Flying Personnel Research Committee, Reports
Gt. Brit., RAE Rep. Great Britain, Royal Aircraft Establishment, Reports
Gt. Brit., RAE RPD Rep. Great Britain, Royal Aircraft Establishment, Rocket Propulsion Department, Reports
Gt. Brit., RAE TN. Great Britain, Royal Aircraft Establishment, Technical Notes
Grumman Aircraft Eng. Corp. Res. Dept. Rep. Grumman Aircraft Engineering Corporation, Research Department, Reports

Handley-Page Bul. Handley-Page Bulletin
Harvard U. BHMO MR Studies; Rep. Harvard University, Blue Hill Meteorological Observatory, Meteorological Radar Studies; Reports
Harvard U. Cruft Lab. TR. Harvard University, Cruft Laboratory, Technical Reports
Hawker Siddeley Rev. Hawker Siddeley Review
Hewlett-Packard J. Hewlett-Packard Journal
La Houille Blanche (France)
Hunting Group Rev. Hunting Group Review
Hydraulic Engr. Hydraulic Engineer

IAS Preprints; Papers. Institute of the Aeronautical Sciences, Preprints; Papers
IATA Bul. International Air Transport Association Bulletin
ICAO Bul. International Civil Aviation Organization Bulletin
IME Auto. Div. Proc. Institution of Mechanical Engineers, Automobile Division, Proceedings
IME Proc. (A). Institution of Mechanical Engineers, Proceedings (A)
IME Proc. (B), Appl. Mech.; Hydraulics. Institution of Mechanical Engineers; Proceedings (B), Applied Mechanics; Hydraulics
INCO. (International Nickel Company, Inc.)
Ind. & Eng. Chem. Industrial and Engineering Chemistry
Ind.-Anzeiger. Industrie-Anzeiger (Essen, Germany)
Ind. Labs. Industrial Laboratories
Ind. Quality Control. Industrial Quality Control
Ind. Sci. & Eng. Industrial Science and Engineering (Advanced-student edition of *Industrial Laboratories*)
Indian AF Quart. Indian Air Force Quarterly
Indian Airman
Indian Skyways
L'Ingegnere (Italy)
Ingen.-Arch. Ingenieur-Archiv (Germany)
Inst. Français Transp. Aérien, Res. Papers. Institut Français du Transport Aérien, Research Papers
Inst. für Praktische Math. Tech. Hochschule. Institut für Praktische Mathematik Technische Hochschule (Darmstadt, Germany)
Inst. Mec. Fluides, Lille. Institut de Mécanique des Fluides de Lille (France)

Two Aerojet-General high-thrust, short-duration solid propellant rocket powerplants boost the Navy's famed REGULUS missile off on its mission.

Built by Chance-Vought, the REGULUS is one of a growing number of available missiles for defensive or offensive applications.

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Aerojet-General supplies liquid and solid propellant rocket powerplants, auxiliary power units, gas generators, or other associated equipment to a major part of America's missile program.

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Inst. Sci. & Tech., Tokyo. Institute of Science and Technology (Japan)
Instrumentation
Instruments & Automation
Interavia (monthly)
Interchem. Rev. Interchemical Review
Internatl. Congr. Appl. Mech. Proc. International Congress for Applied Mechanics, Zurich, Proceedings
Internatl. Nickel Devel. & Res. Div. Tech. Bul. International Nickel Company, Development & Research Division, Technical Bulletins
Iowa Eng. Exp. Sta. Eng. Rep. Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, Engineering Report
IRE Trans. (ANE, AP, CS, EC, MTT Ser.) Institute of Radio Engineers, Transactions, Professional Groups on: Aeronautical and Navigational Electronics; Antennas and Propagation; Communications Systems; Electronic Computers; Microwave Theory and Techniques
Ireland, Meteorological Serv., Geophys. Pubs. Ireland, Meteorological Service, Geophysical Publications
Iron & Steel Engr. Iron and Steel Engineer
ISA J. Instrument Society of America, Journal
Istanbul Tech. U. Bul. Istanbul Technical University, Bulletin

J. Acoustical Soc. Am. Journal of the Acoustical Society of America
J. ACS. Journal of the American Chemical Society
J. Aero. Sci. Journal of the Aeronautical Sciences
J. Aero. Soc. India. Journal of the Aeronautical Society of India
J. Air Law & Commerce. Journal of Air Law & Commerce
J. Appl. Mech. Journal of Applied Mechanics
J. Appl. Phys. Journal of Applied Physics
J. ARS. Journal of the American Rocket Society. See **Jet Propulsion**
J. ASNE. Journal of the American Society of Naval Engineers
J. Atmos. & Terrestrial Phys. Journal of Atmospheric & Terrestrial Physics
J. Av. Med. Journal of Aviation Medicine
J. Brit. Interplanetary Soc. Journal of the British Interplanetary Society
J. Electrodepositors' Tech. Soc. Journal of the Electrodepositors' Technical Society
J. Eng. Educ. Journal of Engineering Education
J. Franklin Inst. Journal of the Franklin Institute
J. GAPAN. Journal of the Guild of Air Pilots and Air Navigators
J. Helicopter Assn. Gt. Brit. Journal of the Helicopter Association of Great Britain
J. Hokkaidô Gakugei U., Sect. B. Journal of Hokkaidô Gakugei University, Section B (Japan)
J. Indian Inst. Sci. Journal of the Indian Institute of Science
J. Inst. Metals. Journal of the Institute of Metals
J. Inst. Navigation. Journal of the Institute of Navigation
J. Inst. Transp. Journal of the Institute of Transport
J. Japan Soc. Appl. Mech. Journal of the Japan Society for Applied Mechanics
J. London Math. Soc. Journal of the London Mathematical Society
J. Math. & Phys. Journal of Mathematics and Physics
J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids
J. Meteorology. Journal of Meteorology
J. RAeS. Journal of the Royal Aeronautical Society
J. Sci. & Ind. Res. Journal of Scientific and Industrial Research
J. Sci. Instr. Journal of Scientific Instruments
J. Sci. Res. Journal for Scientific Research
J. SCMA. Journal of the Southern California Meter Association. In: **Instruments & Automation**
J. SLAE. Journal of the Society of Licensed Aircraft Engineers (incorporating *The Technical Instructor*)
J. Southern Res. Journal of Southern Research
J. Space Flight. Journal of Space Flight
Japan, NCB Rep. Japan, Numerical Computation Bureau, Reports
Japan Sci. Rev. Japan Science Review (Engineering Sciences)
Japan Sci. Rev. Mech. & Elec. Eng. The Japan Science Review, Mechanical & Electrical Engineering
Jet Age
Jet Propulsion. (Formerly, **J. ARS**)

Konstruktion (German)
Konstruktionbucher (Berlin)
Kunstoffe (Munich)
Kyushu U., Japan, Rep. Res. Inst. Appl., Mech. Kyushu University, Japan, Reports of Research Institute for Applied Mechanics

La. State U. Eng. Exp. Sta. Bul. Louisiana State University, Engineering Experiment Station, Bulletin
Lenkurt Demodulator
Lockheed Aircraft Rep. Lockheed Aircraft Corporation, Reports
Lockheed Field Serv. Dig. Lockheed Field Service Digest
The Log
Lubrication
Lubrication Eng. Lubrication Engineering

Mach. Des. Machine Design
Mag. of Magnesium. Magazine of Magnesium
Mag. of Standards. The Magazine of Standards
Magyar Kémiai Folyóirat (Budapest)
Marconi Rev. Marconi Review
Martin Star
Masch. und Wärmewirtschaft. Maschinenbau und Wärmewirtschaft (Austria)
Materials & Methods
Mec. Ind. (France)
Mech. Eng. Mechanical Engineering
Met. & Corrosion. Metaux et Corrosion (France)
Metal Prog. Metal Progress
Metal Treatment
Metall (Berlin)
Metallforschung (Germany)
Metalloberfläche (Munich)
Metallurgia
Metallurgia Italiana (Milan)
Meteorological Mag. The Meteorological Magazine
Mil. Med. Military Medicine
Miss. State U. Eng. Res. Sta. Res. Rep. Mississippi State University, Engineering Research Station, Research Reports
MIT ASRL TR. Massachusetts Institute of Technology, Aeroelastic and Structures Research Laboratory, Technical Reports
Mitteil. Forscharb. Gebiet Ing. Mitteilungen über Forschungsarbeiten auf dem Gebiet des Ingenieurwesens (Berlin)
Mitteil. Hydraulischen Inst. Tech. Hochschule, München. Mitteilungen des Hydraulischen Instituts der Technischen Hochschule, München
Mitteil. Max-Planck-Inst. für Strömungsforschung. Mitteilungen aus dem Max-Planck-Institut für Strömungsforschung (Göttingen)
Modern Metals
Motorola Newsgram

N.C. State Coll. Eng. Sch. Bul. North Carolina State College, Engineering School Bulletin
Nachr. Öst. Betonver. Nachrichten Österreichischner Betonverein (Austria)
Natl. Acad. Sci. NRC Rep. National Academy of Sciences of the United States, National Research Council, Reports
Natl. Assn. State Av. Off. Papers. National Association of State Aviation Officials, Papers
NATO AGARD Memo. North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Memorandum
Naturwissenschaften (Germany)
Naval Av. News. Naval Aviation News
Navigation
Netherlands, Koninklijke Nederlandse Akademie van Wetenschappen, Proc. (Proceedings)
Netherlands, Mathematisch Centrum, Amsterdam, Rep. (Reports)
Netherlands, NLL Rep. (Rep. & Trans.) Netherlands, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), Amsterdam, Reports (Reports and Transactions)
New Frontiers
New Zealand Flying
NFPA Bul.; Papers; Rep. National Fire Protection Association, Bulletins; Papers; Reports
NFPA Comm. Av. & Airport Fire Protection Bul.; Rep. National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletins; Reports
Noise Control
North Amer. Av. Spec. Res. Rep. North American Aviation Corporation, Special Research Reports
NYU Res. Rev. New York University, College of Engineering, Research Review

O. State U. Eng. Exp. Sta. News. The Ohio State University, Engineering Experiment Station, News
L'Onde Elec. L'Onde Electrique (France)
Ordnance
Ore. State Coll. Eng. Exp. Sta. Bul. Oregon State College, Engineering Experiment Station, Bulletin
Organic Finishing
The Oscillographer
Öst. Bauzeitschrift. Östdeutsche Bauzeitschrift (Austria)

Pacific J. Math. Pacific Journal of Mathematics
Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics
Pegasus
Philips Tech. Rev. Philips Technical Review
Philos. Mag. Philosophical Magazine
Philos. Trans. Royal Soc. (London), Ser. A. Philosophical Transactions of the Royal Society of London, Series A, Mathematical and Physical Sciences
Photogrammetria
Photogrammetric Eng. Photogrammetric Engineering
Photographic Eng. Photographic Engineering
Phys. Rev. The Physical Review
Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech. Polytechnic Institute of

Boeing aeronautical engineers have vital and rewarding jobs

The "wraps" are off Boeing's mighty B-52 now. Some of the aeronautical engineers, who were so important in developing "stretch" potential into the B-52, are now at work on its future development. Many more have gone to work on other exciting "years-ahead" airplanes and guided missiles. But these new Boeing aircraft are classified, and cannot be shown here.

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Boeing engineers can point with pride to recent developments like the B-47 and B-52 jet bombers, the KC-135—America's first jet tanker, and the IM-99 Bomarc pilotless interceptor. These Boeing engineers are now at work on widely diversified projects: rocket, ram jet and nuclear propulsion, supersonic flight, research in new materials, and many more. The result will be planes and missiles that will fly even faster, farther, and higher, and deliver an even greater punch.

These are evidences of Boeing's continuing growth—a growth made possible by uncompromising insistence on engineering excellence. Boeing employs twice as many engineers now than at the peak of World War II. But even more engineers are needed for Boeing's research, design and production teams.

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• University or
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• City _____ Zone ____ State _____

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Brooklyn, Department of Aeronautical Engineering and Applied Mechanics
Power Jets Memo. Power Jets (Research and Development) Limited, Memorandum
Princeton U. Dept. Aero. Eng. Rep. Princeton University, Department of Aeronautical Engineering, Reports
Proc. Cambridge Philos. Soc. Proceedings, Cambridge Philosophical Society
Proc. IEE, Part I. Proceedings of the Institution of Electrical Engineers, Part I (General)
Proc. IEE, Part II. Proceedings of the Institution of Electrical Engineers, Part II (Power Engineering)
Proc. IEE, Part III. Proceedings of the Institution of Electrical Engineers, Part III (Radio and Communication Engineering)
Proc. Inst. Electronics. Proceedings of the Institution of Electronics (*Electronics Forum*)
Proc. IRE. Proceedings of the Institute of Radio Engineers
Proc. London Math. Soc., 2nd Ser.; 3rd Ser. Proceedings of the London Mathematical Society, 2nd Series; 3rd Series
Proc. Phys. Soc., Sect. B. Proceedings of the Physical Society (British), Section B
Proc. Royal Netherlands Acad. Sci., Amsterdam, Ser. A; Ser. B; Ser. C. Proceedings of the Royal Netherlands Academy of Sciences at Amsterdam, Series A (Mathematical Sciences); Series B (Physical Sciences, containing, e.g., Astronomy, Chemistry, Geology, Physics, Technical Sciences); Series C (Biological and Medical Sciences)
Proc. Royal Soc. (Edinburgh). Proceedings of the Royal Society (Edinburgh)
Proc. Royal Soc. (London), Ser. A. Proceedings of the Royal Society (London), Series A (Mathematical and Physical Sciences)
Prod. Eng. Product Engineering
Prof. Engr. Professional Engineer
Promotionsarb. Promotionsarbeiten, École Polytechnique Fédérale (Zurich)
Purdue U. TR. Purdue University, Technical Reports

Quadrangle
Quart. Appl. Math. Quarterly of Applied Mathematics
Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics
Quart. J. Royal Meteorological Soc. Quarterly Journal of the Royal Meteorological Society

Radio & TV News. Radio & Television News
Radio-Electronic Eng. Radio-Electronic Engineering Section (formerly a section in **Radio & TV News**)
Radio Tech. Comm. Aeronautics, Papers. Radio Technical Commission for Aeronautics, Papers
RAND Corp. Transl. The RAND Corporation, Translations
RCA Rev. RCA Review
La Recherche Aéronautique (Paris)
Rend. Accad. Naz. dei Lincei, Classe Sci. Fis. Mat. e Natl. Rendiconti dell'-Accademia Nazionale dei Lincei, Classe de Scienze Fisiche, Matematiche e Naturali (Italy)
Rensselaer Polytech. Inst. Dept. Aero. Eng. TR. Rensselaer Polytechnic Institute, Department of Aeronautical Engineering, Technical Reports
Rep. Inst. Sci. & Tech. Report of the Institute of Science and Technology (Tokyo)
Republic Av. Rep. Republic Aviation Corporation, Reports
Res. Trends (Cornell Aero. Lab.). Research Trends (Cornell Aeronautical Laboratory, Inc.)
RETMA Electronic Appl. Reliability Rev. Radio-Electronics-Television Manufacturers Association, Electronic Applications Reliability Review
Rev. Aero. Revista de Aeronáutica (Madrid)
Rev. Nac. Aero. Revista Nacional de Aeronautica (Buenos Aires)
Rev. Sci. Instr. Review of Scientific Instruments
Rev. Universelle des Mines. Revue Universelle des Mines (Liége, Belgium)
Reynolds Metals Tech. Adviser. Reynolds Metals Technical Adviser
Ricerca Sci. La Ricerca Scientifica (Rome)
Riv. Aero. Rivista Aeronautica (Rome)
Rockets
Rolls-Royce Bul. Rolls-Royce Bulletin
Rozprawy Inżynierskie. Instytut Podstawowych Problemów Techniki, Polska Akademia Nauk (Warsaw)
Ryan Reporter

Saab Sonics (Sweden)
Saab TN. Saab Technical Notes
SAE Aero. Info. Rep. Society of Automotive Engineers, Aeronautical Information Reports
SAE J. SAE Journal
SAE Preprints; Papers. Society of Automotive Engineers, Preprints; Papers
Sailplane & Glider
Saro Prog. Saro Progress
Schweissen und Schneiden (Germany)
Schweizer Arch. (Switzerland)
Sci. Mo. The Scientific Monthly
Science
Sheet Metal Ind. Sheet Metal Industries
Shell Av. News. Shell Aviation News
Siemenstadt, Mitt. Forsch. Lab. Siemenstadt, Mitteilung und Forschung Laboratorium (Germany)
Skyline (North American Aviation, Inc.)
Skyways
SNCASO Papers. Société Nationale de Constructions Aéronautiques du Sud-Ouest, Papers
Soaring
Solar Blast
SPE J. Society of Plastics Engineers, Journal
Sperry Eng. Rev. Sperry Engineering Review
Sperry Gyroscope Rep. Sperry Gyroscope Company, Reports
Sperry Rev. Sperry Review
Sperryscope
Stahl und Eisen (Düsseldorf, Germany)
Stanford Res. Inst. Res. Ind. Stanford Research Institute, Research for Industry
State Coll. Ia. Eng. Sta. TR. State College of Iowa, Engineering Experiment Station, Technical Reports
Steel Horizons
Steel Processing
Stockholm, KTH AERO TN. Stockholm, Kungliga Tekniska Högskolan, Institutionen för Flygteknik, Technical Notes
Stockholm, KTH IBS Medd. Stockholm, Kungliga Tekniska Högskolan, Institutionen för Byggnadsstatik, Meddelanden
Structural Engr. Assn. Calif. Rep. Structural Engineers Association of California, Reports
Stuttgart Tech. Hochsch. Stuttgart Technische Hochschule (Germany)
Sverdrup & Parcel Transl. Rep. Sverdrup & Parcel, Inc., Translation Reports
Sweden, Flygtekniska Försöksanstalten, FFA Medd. (The Aeronautical Research Institute of Sweden, Reports)
Syracuse U. Transp. Conf. Papers. Syracuse University, Transportation Conference, Papers

Taylor Tech. Taylor Technology
Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques (Paris)
Tech. Rev. Technology Review
Tek. Lotnioza. Teknika Lotnioza (Poland)
Teknisk Ukeblad (Norway)
Tele-Tech
Tôhoku U. (Japan) Rep. Inst. High Speed Mech. Tôhoku University, Sendai, Japan, The Reports of the Institute of High Speed Mechanics. The Science Reports of the Research Institutes, Series B (Technology)
Tool Engr. Tool Engineer
Trans. AIEE. Transactions of the American Institute of Electrical Engineers
Trans. ASME. Transactions of the American Society of Mechanical Engineers
Trans. Inst. Welding. Transactions of the Institute of Welding
Trans. Soc. Inst. Tech. Transactions of the Society of Instrument Technology
Transp. & Commun. Rev. Transport and Communications Review
Trend in Eng. The Trend in Engineering

U. Ark. Engr. Exp. Sta. Bul. University of Arkansas, Engineering Experiment Station, Bulletin
U. Calif. Pubs. in Eng. University of California, Publications in Engineering
U. Ill. Bul. University of Illinois, Bulletins
U. Ill. Eng. Exp. Sta. Bul.; TR. University of Illinois, Engineering Experiment Station, Bulletins; Technical Reports
U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. University of Maryland, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series
U. Mich. Eng. Res. Inst. Rep. University of Michigan, Engineering Research Institute, Reports
U. Mich. Icing Res. Cen. Rep.; Transl. University of Michigan, Icing Research Center, Reports; Translations
U. Minn. Inst. Tech. Dept. Aero. Eng., Res. Rep. University of Minnesota, Institute of Technology, Department of Aeronautical Engineering, Research Reports
U. Nac. Eva Peron, Fac. Ciencias Fisicomat., Pubs. Universidad Nacional Eva Peron, Publicaciones de la Facultad de Ciencias Fisicomatematicas
U. Toronto Inst. Aerophys. Rev.; Rep. University of Toronto, Institute of Aerophysics, Review; Reports
U. Wash. Eng. Exp. Sta. Bul.; Reprints. University of Washington, Engineering Experiment Station, Bulletins; Reprints
U. Wis. NRL Dept. Chem. Rep. University of Wisconsin, Naval Research Laboratory, Department of Chemistry, Reports
United Air Lines News
U.S., Bur. Mines Bul.; Rep. Invest. United States, Bureau of Mines, Bulletin; Report of Investigations
U.S., CAA AEE Rep. United States, Civil Aeronautics Administration, Airframe and Equipment Engineering Reports
U.S., CAA TDR. United States, Civil Aeronautics Administration, Technical Development Reports
U.S., Dept. of Comm., Bus. & Defense Serv. Admin., Pamphlets; Reps. United States, Department of Commerce, Business and Defense Services Administration, Pamphlets; Reports

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U.S., Forest Prod. Lab. Rep. United States, Forest Products Laboratory, Madison, Wis., Reports
U.S., NACA Rep.; RM; TM; TN. United States, National Advisory Committee for Aeronautics, Report; Research Memorandum; Technical Memorandum; Technical Notes
U.S., NADC Rep. U.S., Naval Air Development Center, Reports
U.S., NAES Rep. United States, Naval Air Experiment Station, Reports
U.S., Nav. Sch. Av. Med., Pensacola, Fla., Project Rep. United States, Naval School of Aviation Medicine, Naval Air Station, Florida, Project Reports
U.S., NavBuAer RDR. United States, Navy Department, Bureau of Aeronautics, Research Division Reports
U.S., NAVORD Rep. United States, Naval Ordnance Reports
U.S., Navy Dept., David W. Taylor Model Basin, Rep.; Transl. United States, Navy Department, David W. Taylor Model Basin, Reports; Translations
U.S., NBS Appl. Math. Ser. United States, National Bureau of Standards, Applied Mathematics Series
U.S., NBS J. Res. United States, National Bureau of Standards, Journal of Research
U.S., NBS Sum. TR. United States, National Bureau of Standards, Summary Technical Reports
U.S., NBS Tech. News Bul. United States, National Bureau of Standards, Technical News Bulletin
U.S., NRL Rep. United States, Naval Research Laboratory, Reports
U.S., ONR Res. Rep. United States, Office of Naval Research, Research Report (monthly)
U.S., ONR Special Devices Cen. TR. United States, Office of Naval Research, Special Devices Center, Technical Reports
U.S., Weather Bur. Mo. Weather Rev. United States, Weather Bureau, Monthly Weather Review
U.S. AEC Rep. United States Atomic Energy Commission, Reports
U.S. Air Serv. U.S. Air Services
U.S. Armed Forces Med. J. United States Armed Forces Medical Journal
U.S. Naval Inst. Proc. United States Naval Institute, Proceedings
U.S. Steel Lubricants Testing Lab. Rep. United States Steel Lubricants Testing Laboratory, Reports
USAF AMC Eng. Div. Aero. Med. Lab. TR. United States Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Technical Reports
USAF APG Rep. United States Air Force, Air Proving Ground, Reports
USAF Arctic Aeromed. Lab. Project Rep. United States Air Force, Arctic Aeromedical Laboratory, Alaska, Project Reports
USAF MATS Rep.; Papers. United States Air Force, Military Air Transport Service, Reports; Papers
USAF SAM Rep. United States Air Force, School of Aviation Medicine, Reports
USAF TR. United States Air Force, Technical Reports

Va. J. Sci. The Virginia Journal of Science
VDE Fachber. Verein Deutscher Elektrotechniker, Fachberichte (Germany)
VDI-Forschungsheft. Vereines Deutscher Ingenieure, Verlag, Forschungsheft (Düsseldorf, Germany)
VPI Eng. Exp. Sta. Ser. Bul. Virginia Polytechnic Institute, Engineering Experiment Station, Series Bulletin
VTH. Vliegtuigbouwkunde Technische Hogeschool (Delft)
W. U. Tech. Rev. Western Union Technical Review
Welding J. Welding Journal
Welding J. Res. Suppl. Welding Journal, Research Supplement
Welding Res. Welding Research (London)
Weltraumfahrt (Frankfurt am Main)
Western Av. Western Aviation
Westinghouse Engr. Westinghouse Engineer
Whites' Av. Whites' Aviation
Wireless Engr. Wireless Engineer
Wireless World
WMO Bul. World Meteorological Organization Bulletin

Z. für Elektrochemie. Zeitschrift für Elektrochemie (Halle, Germany)
Z. für Instrumenkunde. Zeitschrift für Instrumenkunde (Berlin)
Z. für Metallkunde. Zeitshrift für Metallkunde (Germany)
Z. für Naturf. Zeitschrift für Naturforschung (Wiesbaden, Germany)
Z. VDI. Zeitschrift des Vereins Deutscher Ingenieure (Berlin)
ZAMM. Zeitschrift für angewandte Mathematik und Mechanik (Berlin)
ZAMP. Zeitschrift für angewandte Mathematik und Physik (Zurich)
ZAP. Zeitschrift für angewandte Physik (Berlin)
ZFW. Zeitschrift für Flugwissenschaften (Braunschweig)
Zhur. Tekh. Fiz. Zhurnal Tekhnischeskoi Fiziki (Moscow)
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Aerodynamics

Boundary Layer

The Interaction Between Shock Waves and Boundary Layers, with a Note on the Effects of the Interaction on the Performance of Supersonic Intakes. D. W. Holder, H. H. Pearcey, G. E. Gadd, and J. Seddon. *Gt. Brit., ARC CP 180* (Feb. 2, 1954), 1955. 102 pp. 66 refs. BIS, New York. $2.00.

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liquid medium and of related basic problems.

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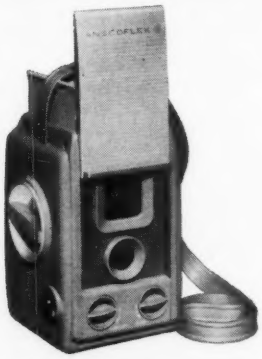
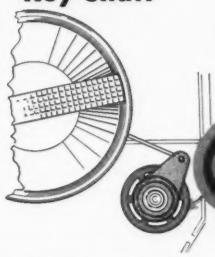
5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera



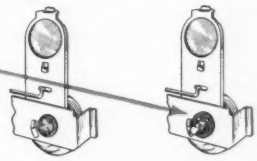
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

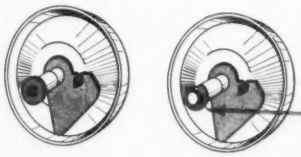
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



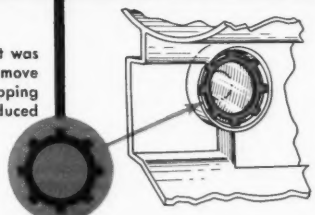
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-topping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

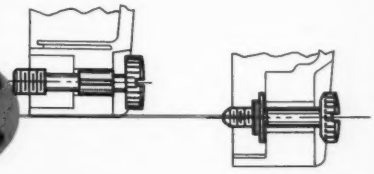


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

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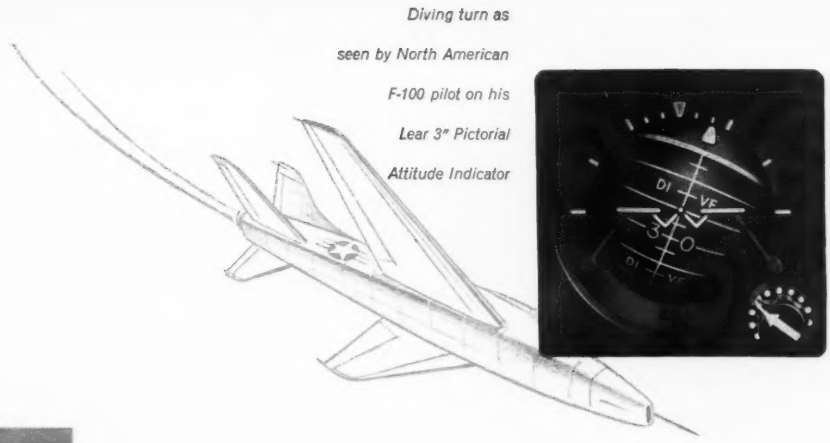

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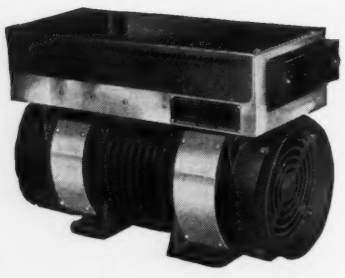

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12126	27.5	2	26	3	10	2.3	35000	N1020-SK
MG-93	27.5	12	115/200	1	100	10	65000	E-5134
				3	100			
MG-54	27.5	22	115/200	1	250	17	65000	E-5109
				3	250			
12142	27.5	22	115	1	250	13	35000	E-1617
				3	250			
12146-1	27.5	22	115	1	250	13	35000	53B6239
12146-2	27.5	22	115	3	250	13	35000	AN3532-2
MG-60	27.5	22	115	1	250	17	50000	53B6239
MG-62	27.5	22	115	3	250	17	50000	AN3532-2
32E01	27.5	35	115	1	500	26	50000	AN3533-1
				3	500			
32E00	27.5	37.5	115	1	500	34	50000	AN3534-1
		51.5		3	750			
MG-65	27.5	50	115/200	1	750	35	50000	E53805
		52		3	750			
1518 Mod. 1 & 2	27.5	105	115	1	1500	37.5	20000	—
		126		3	1800			
1518 Mod. 5	27.5	105	115	1	1500	37.5	35000	—
		126		3	1800			
MG-81	27.5	180	115/200	1	1600	61	65000	E1725
				3	1800			
32E06	27.5	150	115/200	1	2250	56	50000	E1725
		160		3	2500			
MG-70	27.5	170	115/200	1	2250	54	65000	—
				3	2500			
MG-61	27.5	170	115	1	2500	54	65000	53C6767
MG-64	27.5	170	115	3	2500	54	65000	—
32E03	27.5	160	115	1	2500	61	50000	53B6227
MG-95	27.5	150	115/200	1	2500	54	50000	E54807
		160		3	3000			
32E09	27.5	180	115/200	1	2500	60	50000	—
				3	3000			

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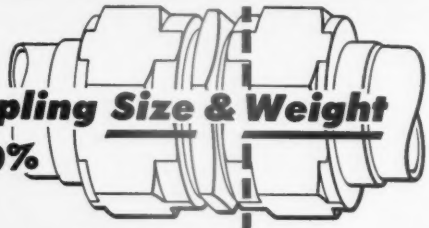

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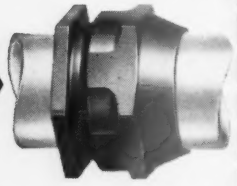

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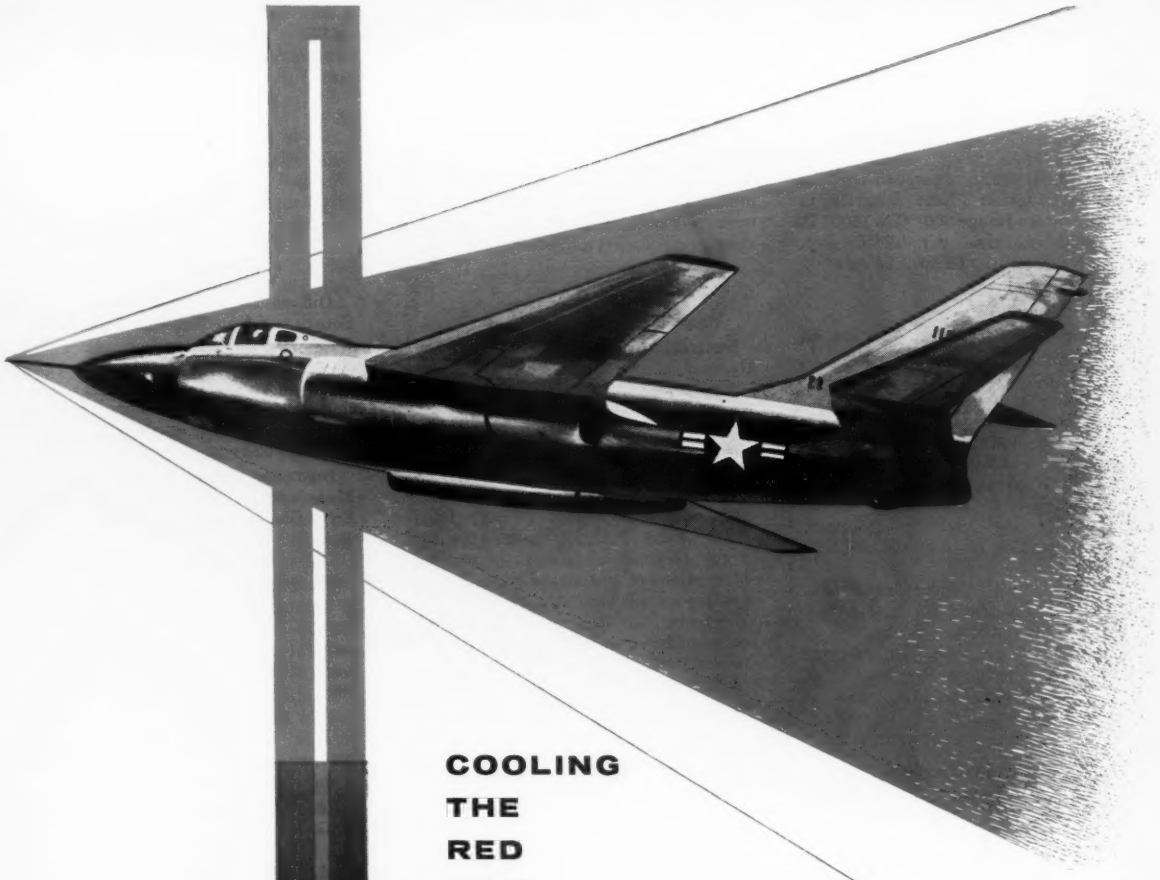

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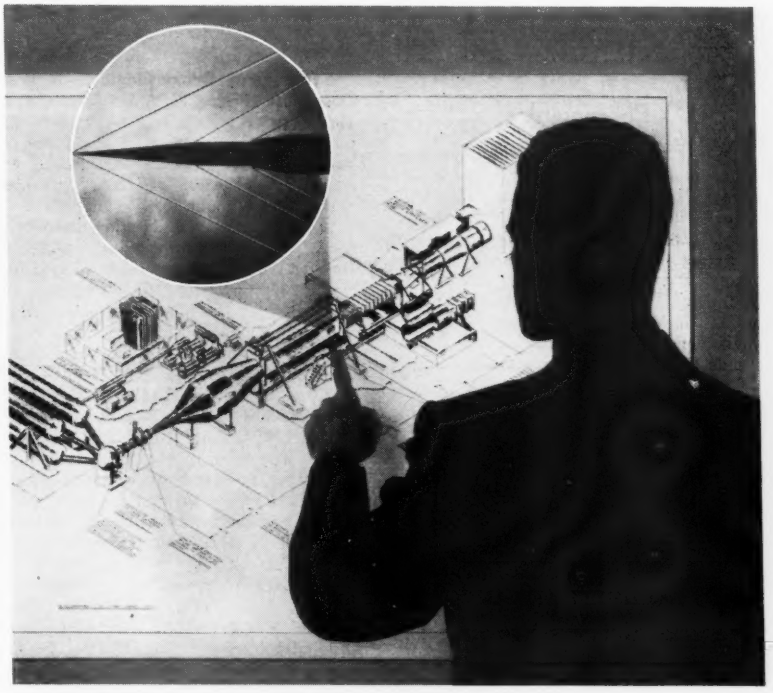

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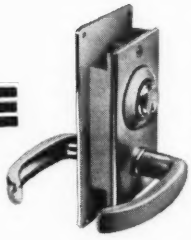
ADAMS-RITE  LOCKS AND LATCHES

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An unabridged republication of the fourth edition issued by Cambridge University Press in 1925.

Sailing Aerodynamics. John Morwood. New York, Philosophical Library, Inc., 1954. 124 pp., diagrs., figs. $7.50.

This volume, which is intended for yachtsmen primarily, presents calculations from which are derived performance figures for sails and airfoils. The equations and mathematics used are only the most elementary trigonometry. The methods by which the performance figures have been obtained are given so that not only the author's figures may be checked but also other figures may be obtained for other airfoils and sales. No attempt has been made to give more of aerodynamic theory than is necessary to understand the principles of airflow around an airfoil and the basic figures on which *Sailing Aerodynamics* are founded. More advanced facts and theory may be obtained from books on airplane aerodynamics to which those interested should refer. Several inventions of the author are also included in the text.

COMPUTERS

Analog Methods in Computation and Simulation. Walter W. Soroka. New York, McGraw-Hill Book Co., Inc., 1954. 390 pp., diagrs., figs. $7.50.

This textbook for engineers is based on class notes used at the University of California, where the author is Professor of Engineering Design. In the opening chapters, analogies are developed for various arithmetical processes, and these are combined into analog computers for linear simultaneous algebraic equations, polynomial equations, and ordinary differential equations. The mechanical differential analyzer and the electronic analog computer are discussed in this connection. In the seventh chapter, the dynamical similarity between electrical circuits and mechanical systems is taken as the basis for representing mechanical systems in lumped form by equivalent electrical circuits with lumped parameters. In the eighth chapter, ordinary and partial differential equations of various degrees of complexity, linear and nonlinear, are expressed in finite differences, and electrical networks are developed for their solution. The final chapter is devoted to a study of membranes and of electrically conducting sheets as simulating devices for continuous systems. The text is not intended to be an exhaustive treatment of the field of analogies and analog computers, and accordingly numerous applications in specialized fields have been omitted. On the other side, the broad review and the many references presented should serve to point out the usefulness of analogies and to lead individuals to more intensive studies of special problems of interest to them.

CONFERENCES

Jahrbuch 1953 der Wissenschaftlichen Gesellschaft für Luftfahrt e.v. (WGL). Herausgegeben von Hermann Blenk. Braunschweig, Friedr. Vieweg & Sohn, 1954. 224 pp., illus., diagrs., figs. DM 28.–.

The WGL presents in this yearbook the lectures delivered at the Annual Conference held in Göttingen May 26–29, 1953. The first 31 pages are devoted to reports on activities and membership of the WGL. The remainder is devoted to the papers presented at the Conference, as follows: Wege der Forschung, A. Betz. Tragflächentheorie bei inkompressibler Strömung, E. Truckenbrodt. The calculation of the profile drag of aerofoils and bodies of revolution at supersonic speeds, A. D. Young. Der Stand des Leewellenproblems, J. Zierep. Windkanalversuche zum Studium des Flatterverhaltens eines Nurflügelflugzeuges (Einführung in einen Film), H. Wittmeyer. Vibrations d'aubes d'un compresseur axial, S. Boudigues. Einige Bemerkungen über den Angriff des Strahltriebwerksschubes an Flugzeugzellen, A. W. Quick and H. Söhngen. Der Grenzschichtzaun, W. Liebe. Étude des écoulements transsoniques; Contrôle expérimental des régles de similitude, L. Malavard. Résultats concernant la structure des ondes de choc, M. J. Bernard. Étude aérodynamique des trompes supersoniques, J. Fabri, E. Le Grivès, and R. Siestrunck. Geschwindigkeit, Konstruktionsgewicht und Nutzlast moderner Verkehrsflugzeuge, K. Thalau. Der Einfluss der Anfangsbedingungen auf die Entwicklung der laminaren kompressiblen Grenzschicht in zwei Dimensionen, E. A. Eichelbrenner. Strömungsbilder an Profilen bei hohen Geschwindigkeiten, A. Naumann. Allgemeine Probleme der Grestzschichteuerung, G. V. Lachmann. Unicité des Écoulements avec chocs dans la méchanique de Burgers, P. Germain, and R. Bader. Über die Aerodynamik der kleinen Reynolds-Zahlen, F. W. Schmitz. Erste Ergebnisse der deutschen Böenmessungen, H. Koschmieder, Zur experimentellen Leewellenforschung (Film), W. Klemperer. Sprödbruch von Schweissverbindungen; das Nichtschmelzschweissen, C. Torre. Einige Probleme bei Raketenantrieben, O. Lutz. Rückblick auf die deutsche Entwicklung auf dem Gebiet der Funkmesstechnik, H. Diehl. Planung und Bau von Hubschrauberflughäfen, W. Triebel. Über Stabilitätsprobleme gasförmiger Grenzschichten, W. Tollmien.

Proceedings of the Third AGARD General Assembly, London, 3–11 September 1953. (AG 6/P 3.) Paris, AGARD, 1954. 116 pp., illus., diagrs., figs. (Available in the United States through NACA, Washington.)

Part I contains the introductory addresses that preceded the Joint Technical Meeting, which is reported in Part II. The technical papers reproduced in this Part are: The Review of Icing Research, E. A. Brun. Thoughts on Future Noise Suppression Research, E. J. Richards. The Influence of Aerodynamic Heating on Aircraft Structures, N. J. Hoff. Foundations of Operational Research, E. G. Dickins. Aeromedical Interests—Looking Forward, O. O. Benson, Jr. Examples of NATO Exchange of Scientific Personnel, M. Brull.

ELECTRONICS

Elsevier's Dictionary of Television, Radar and Antennas in Six Languages; English/American, French, Spanish, Italian, Dutch, and German. Compiled and Arranged on an English Alphabetical Base by W. E. Clason. Houston, Elsevier Publishing Company, 1955. $21.50.

In planning this new dictionary the author and publisher have been guided by certain principles proposed by UNESCO. The object of these principles is to ensure that the volume shall fit into place in a pattern that, they hope, may progressively extend over all interrelated fields and cover all necessary languages. The basic word list, consisting of approximately 2,500 terms, is English (British and American usages being clearly distinguished), and definitions in English are included for each subject. The other languages have alphabetical word lists numerically keyed to the English list. Corresponding words in the several languages are arranged horizontally. Languages have been arranged in Anglo-Saxon, Latin, and Germanic groups. The handy size and

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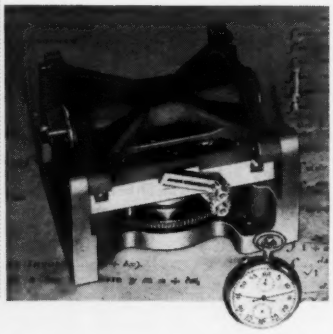

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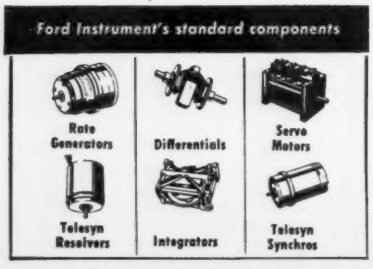


flexible binding should make this dictionary a reference book of permanent value. The compiler has been in charge of all matters concerning bibliography, documentation, and translation in the Phillips' Electrical Works, Endhoven, the Netherlands.

Electronic Circuits. Thomas L. Martin, Jr. New York, Prentice-Hall, Inc., 1955. 707 pp., diagrs., figs. $12.

This book presents the fundamental principles and techniques associated with electronic circuits without emphasizing particular components or system applications. Part I is a brief introduction to the principles of equivalent circuits and the elements of electric circuit theory based on the complex frequency and Laplace transform approach. Parts II and III are the main sections of the book. Most of the usual and some unusual circuits using nearly all the various components are presented. All circuits covered in Part II require continuous operation of the electronic component. This is defined in this book as operation in the switching mode. The approach is almost entirely analytical. Although many useful methods from advanced mathematics are avoided, the book is still mathematical in nature. Many useful and informative results, formulas, and design charts are obtained, but the emphasis is on the techniques used rather than the results themselves. The book presents the methods of formulating circuits to obtain useful design formulas and performance criteria and should appeal to a diversified group of readers. Practicing engineers and physicists will find it a usable reference in their everyday work with circuit design and development. It can also be used as a textbook at the graduate or undergraduate level covering a two- or three-semester sequence of courses.

Networks, Lines, and Fields. John D. Ryder. 2nd Ed. New York, Prentice-Hall, Inc., 1955. 593 pp., diagrs., figs. $7.65.

An expanded revision featuring an abundance of new material in network manipulation and design, reactive networks, the transmission line as viewed at power frequencies, and the antenna for radiation into space.

ENGINEERS

Professional Look at the Engineering in Industry. Washington, National Society of Professional Engineers, 1955. 124 pp., figs. $3.00.

MACHINE ELEMENTS

Helical Spring Tables. John D. Gayer and Paul H. Stone, Jr. New York, The Industrial Press, 1955. 165 pp., diagrs. $5.00.

A handy index of over 6,800 ready-designed compression and tension springs from which selections may be made, with minimum calculation, to meet a wide range of design requirements.

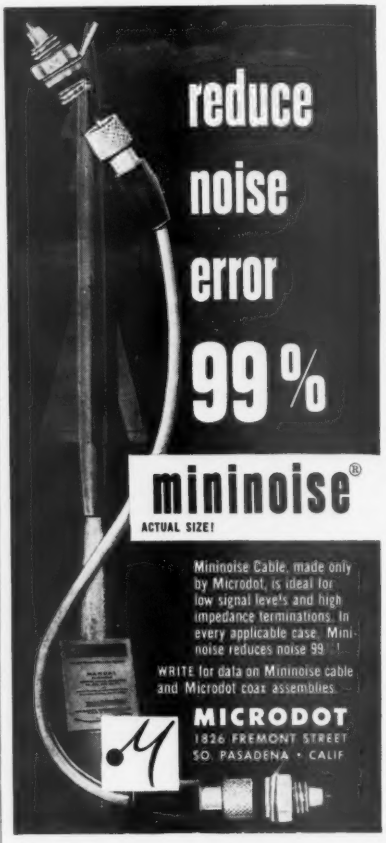
MATERIALS

Fatigue of Metals and Structures. H. J. Grover, S. A. Gordon, and L. R. Jackson, Battelle Memorial Institute. Prepared for Bureau of Aeronautics, Department of the Navy. (NAVAER 00-25-534). Washington, Superintendent of Documents, 1954. 394 pp., illus., diagrs., figs. $2.50.

Battelle Memorial Institute was commissioned by the Navy Bureau of Aeronautics to survey the present state of knowledge and to prepare the manuscript of a book to provide additional help to the designer. This book is directed particularly to the designer or engineer with some knowledge of but limited practical experience in fatigue problems. It is intended to provide a summary of present-day information and to provide references to published literature for more complete information on the most important items in such design.

American Society for Testing Materials, Proceedings, Vol. 54, 1954. Philadelphia, 1955. 1,412 pp., illus., diagrs., figs. $12.

The *Proceedings of the ASTM* are published annually and include all reports and papers offered to the Society during the current year and accepted by the Administrative Committee on Papers and Publications for the Proceedings, to-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gether with discussion. The table of contents and subject and author indexes cover all papers and reports published by the Society during the current year which, in addition to those appearing in the *Proceedings*, include those accepted for publication in the *ASTM Bulletin* or in *Special Technical Publications*. A list of the *Special Technical Publications* published by the Society in 1954 is given in this volume. This supplements the lists appearing in the *Proceedings* from 1948 to 1953 covering all special publications published by the Society up to and including 1953.

Symposium; Ultra High Strength Steels in Aircraft Applications; Seminar Presented at University of California, March 23, 25, and 30, 1953. (SAE Special Publication SP-120.) New York, Society of Automotive Engineers, Inc., 1953. 73 pp., figs. $5.00.

Contents: Composition and Heat Treatment of High Strength Steels, Cyril Wells. The Development of Steel for Use at High Strength Levels, J. M. Hodge, R. D. Manning, and J. A. Bauscher. Development of a Steel for the 280,000 to 300,000 Psi Tensile Strength Bracket, J. W. Sands. Processing of High Strength Steel Parts, C. E. Moeller. Processing of Highly Heat Treated Steel, G. G. Wald. Design Considerations in the Use of Ultra High Strength Alloy Steels in Aircraft, D. A. Redwine.

MATHEMATICS

The Continuum and Other Types of Serial Order; With an Introduction to Cantor's Transfinite Numbers. Edward V. Huntington. 2nd Ed. New York, Dover Publications, Inc., 1955. 82 pp., diagrs., figs. Paperbound, $1.00; clothbound, $2.75.

A reprint of the edition published by the Harvard University Press. The main object of this book is to give a systematic elementary account of the modern theory of the continuum as a type of serial order—a theory that underlies the definition of irrational numbers and makes possible a rigorous treatment of the real number system of algebra.

Almost Periodic Functions. A. S. Besicovitch. New York, Dover Publications, Inc., 1954. 180 pp., diagrs., figs. Paperbound, $1.75. clothbound, $3.50.

A reissue of the first edition published in 1932 by Cambridge University Press.

MECHANICS

The Advanced Part of a Treatise on the Dynamics of a System of Rigid Bodies; Being Part II of a Treatise on the Whole Subject with Numerous Examples. Edward John Routh. 6th Ed. New York, Dover Publications, Inc., 1955. 484 pp., diagrs., figs. Paperbound, $1.95; clothbound, $3.95.

An unabridged republication of the sixth edition published in 1905 by The Macmillan Company.

ROTATING WING AIRCRAFT

Proceedings of the 11th Annual Forum, American Helicopter Society; Held in Washington, April 27–30, 1955. New York, American Helicopter Society, Inc., 1955. 172 pp., illus., diagrs., figs. $6.75 ($3.75 to AHS Members).

Contents: Whirling-Arm Study of Wing Helicopters, Wesley L. Cresap and George Galerstein. Remarks on the Unloaded Rotor Type of Convertiplane, Kurt H. Hohenemser. The Bristol Type 173–Design, Development, and Experiences, Raoul Hafner. Development of the Cessna CH-1 Helicopter, Charles M. Seibel. Rotor Speed Control for Free Turbine Engines in Multi-Engine Helicopters, R. H. Rosenberg and R. L. Paquette. Application of Helicopter Flight Simulators for Training and Research Purposes, P. de Guillenschmidt. Contact Flight Simulator, Thomas R. Harriman. Preliminary Investigation of the Kármán-Yuan Helicopter Rotor System, S. W. Yuan. Effect of Blade Stalling and Drag Divergence on Power Required by a Helicopter Rotor at High Forward Speed, Kenneth B. Amer. The Helicopter Activities of British European Airways, Reginald Brie. Design Requirements for Transport Type Helicopters, J. E. Gallagher. The Operation of Okanagan Helicopters Ltd., Carlyle C. Agar. The Regulatory Aspects of Helicopter Operations, K. S. Cooper. The Helicopter Take-Off Problem, R. B. Lightfoot. Equipment for Blind Approaches, G. S. Hislop. Future Heliports, Martin A. Warskow. Helicopter Navigation, W. W. Bush. Instrumentation for Helicopter Navigation, D. G. C. Luck. Addendum to 10th Annual Forum, 1954: Theory of Rotor Blade Uncoupled Lag Bending Aero-Elastic Vibrations, Peter F. Leone.

Aerodynamics and Performance of Helicopters. Alexander Klemin and Igor A. Sikorsky. Edited by Alfred Gessow. (Rotary Wing Aircraft Handbooks and History; Eugene K. Lideratore, Editor. Vol. 6.) Prepared for WADC, ARDC, USAF, WPAFB, Ohio. Washington, Office of Technical Services, 1954. 71 pp., diagrs., figs. $2.00; PB 111390.

Presented in this volume is a summary of modern practice in aerodynamics and performance calculations. Chart methods are used to simplify calculations. An extensive list of symbols, equations, and definitions is given at the beginning of the volume and serves as a ready reference. Also included are curves of empirical data that are of use in aerodynamics and performance work.

Convertible Airplane. Eugene K. Liberatore. (Rotary Wing Aircraft Handbooks and History; Eugene K. Liberatore, Editor. Vol. 13.) Prepared for WADC, ARDC, USAF, WPAFB, Ohio. Washington, Office of Technical Services, 1954. 79 pp., illus., diagrs., figs. $2.00; PB 111288.

Presented in Volume 13 is an account of the development of convertible aircraft. An attempt has been made to classify the work according to a convertible aircraft family tree. Typical sketches of the configurations are given, and their relation to actual types is shown. The data are given in alphabetical order according to the name of the inventor or designer.

The Rotary Wing Industry. Eugene K. Liberatore. (Rotary Wing Aircraft Handbooks and History; Eugene K. Liberatore, Editor. Vol. 14.) Prepared for WADC, ARDC, USAF, WPAFB, Ohio. Washington, Office of Technical Services, 1954. 71 pp. $2.00; PB 111391.

This volume primarily contains a list of names and addresses of individuals and organizations associated with the rotary-wing industry. An attempt was made to indicate the active or inactive status of the names listed; also, a date is given indicating the year the firm or individual was last known to be active.

Contents: I, Introduction. II, Chronology of Rotary Wing Flight. III, Helicopter Manufacturers and Designers; A, Britain; B, France; C, Germany; D, Other Foreign; E, U.S.A. IV, Institutions for Rotary Wing Research. V, Operators. VI, Powerplant Manufacturers. VII, Rotor Blade Manufacturers. VIII, Other Components. IX, Societies. X, Personalities, Past and Present. XI, Helicopter Production.

Stability and Control of Rotary Wing Aircraft. William E. Cobey. (Rotary Wing Aircraft Handbooks and History; Eugene K. Liberatore, Editor. Vol. 10.) Prepared for WADC, ARDC, USAF, WPAFB, Ohio. Washington, Office of Technical Services, 1954. 64 pp., diagrs., figs. $2.00; PB 111521.

The principles of helicopter stability are here treated in a manner that should prove interesting to design engineers and to those technical people who desire a thorough understanding of the subject without undertaking it on a higher mathematical level. Abstracts of the more important papers are given in the appendix.

Vibrations Handbook for Helicopters. Robert A. Wagner. (Rotary Wing Aircraft Handbooks and History; Eugene K. Liberatore, Editor. Vol. 7.) Prepared for WADC, ARDC, USAF, WPAFB, Ohio. Washington, Office of Technical Services, 1954. 73 pp., figs. $2.00; PB 111289.

This volume considers the important vibratory problems in regard to helicopters. Generally, the coupled vibrations are treated in detail. References are cited and discussed for the relatively simpler uncoupled vibrations.

SERVOMECHANISMS

Servomechanism Practice. William R. Ahrendt. New York, McGraw-Hill Book Company, Inc., 1954. 349 pp., illus., diagrs., figs. $7.00.

This book developed from a need to supplement the theory in a college course on servomechanisms with material on circuitry, electrical and mechanical components, and practical problems encountered in servo design and manufacture. The present volume is an outgrowth of lecture notes and is based on the author's experience and references to reports and the literature. To make the book more useful, component values are given in the circuit diagrams. Tables of characteristics of typical components are also presented. Since the data in these tables are representative and may have been changed, it is not advisable to use the information without checking the manufacturer's latest specifications. Also, some of the data are dependent upon operating conditions that are not specified in the tables. The nomenclature and symbolism used are as currently given by the ASME and the AIEE.

Contents: Operation of a Simple Servomechanism. Potentiometers. Synchros and Related Error Detectors. Double-Speed Synchronizing Networks. Demodulators and Modulators. Networks, Electronic Amplifiers. Rate Generators. Servomotors. Friction Dampers. Magnetic Amplifiers. Rotating Amplifiers. Hydraulic Systems. Manufacture of Servomechanisms. Servomechanism Adjustment and Trouble Shooting. Tests of Servomechanisms. A Typical Servomechanism and Its Operation. Problems. Bibliography. Glossary of Terms. Appendix. Index.

SPACE TRAVEL

Frontier to Space. Eric Burgess. New York, The Macmillan Company, 1955. 174 pp., illus., diagrs., figs. $4.50.

An introduction to the subject of high-altitude rocket research which collates most of the modern data and provides the serious student with a useful collection of references to technical papers for further study.

ENGINEERS

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